HOW IT WORKS

101 *Amazing* FACTS you need to know

Digital Edition

FUTURE

EIGHTH EDITION

Welcome to

101 *Amazing* FACTS
you need to know

Why do boomerangs come back? Do penguins get cold feet?? How does GPS work? What are constellations? For the answers to these questions and many more, look no further than this new collection of conundrums and curiosities from six fascinating subject areas. Covering the environment, technology, science, space, transport and history, each section is packed with amazing facts to satisfy even the hungriest of minds.

101 Amazing FACTS you need to know

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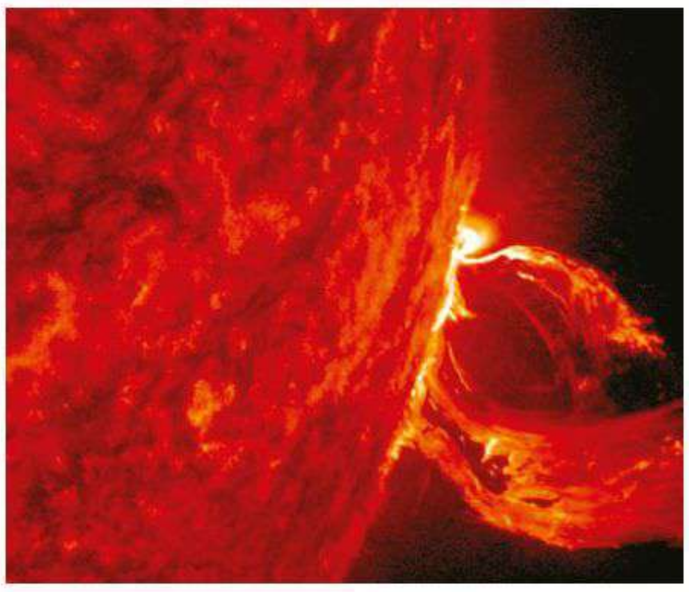

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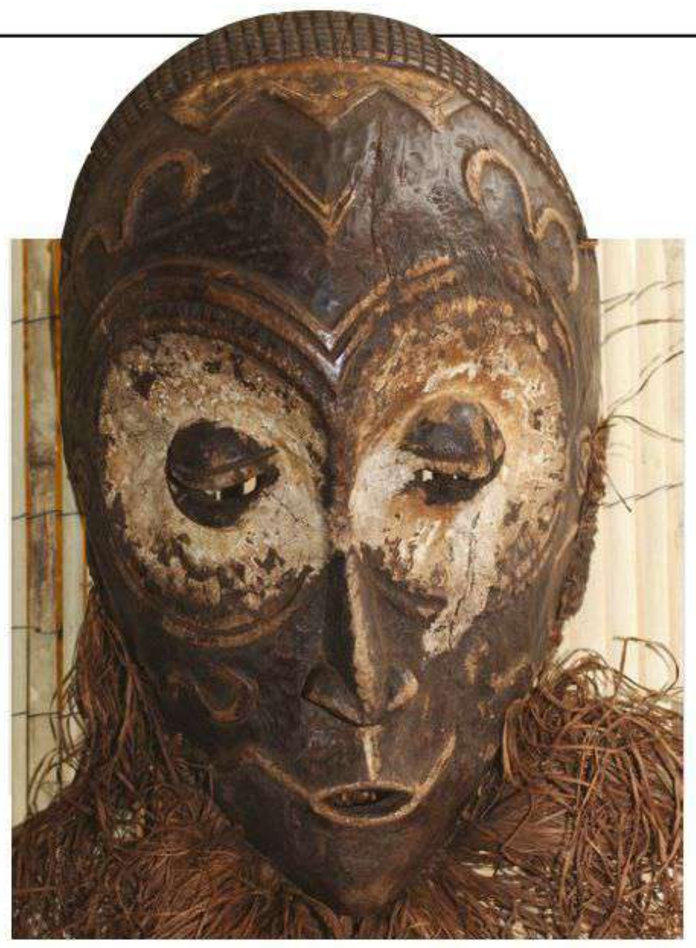


History

© Alamy

© NASA, Thinkstock

Why does the Skeleton Coast exist?

Discover why so many shipwrecks can be found on the coast of Namibia

Along the northern stretch of the Namibian coastline in western Africa, the desert sands are littered with the remains of ships and the bones of their ill-fated crew. The reason so many have met their fate on these shores is because of the region's unusual climatic conditions.

Shipwrecked in the desert

One of the Skeleton Coast's most famous shipwrecks can be found far from the ocean

Shifting coastline

Over time, the desert has slowly encroached on the ocean, moving the shoreline westwards.

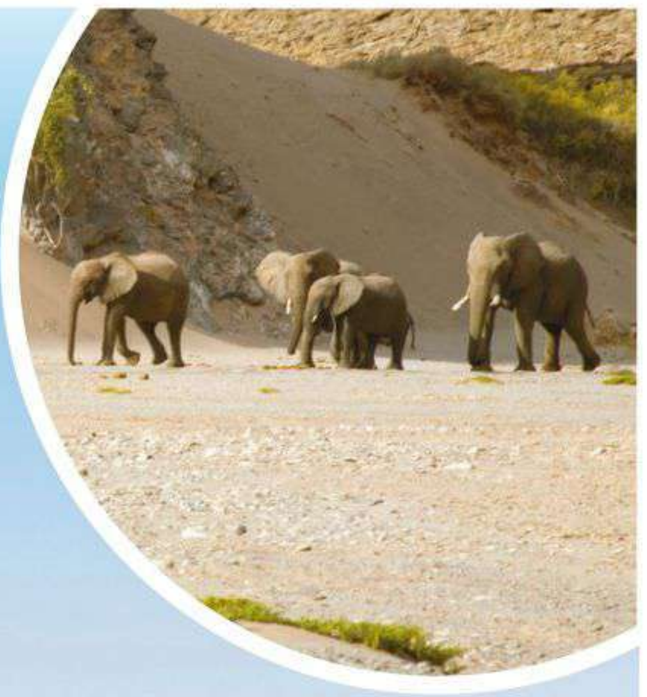
Tragedy strikes

The Eduard Bohlen was a German cargo ship that ran aground on the Skeleton Coast in 1909.

Left
The remnants of many ill-fated ships can be found along the Skeleton Coast

The warm, dry air of the Namib Desert colliding with the cold water of the Atlantic's Benguela Current creates a dense fog over the sea. The poor visibility combined with the strong force of the current and winds have made it difficult for ships to navigate safely along the treacherous coast, causing many to run aground. The crew members that managed to survive the initial wrecks were then faced with crossing the seemingly never-ending desolate desert wilderness in search of food and water.

Many sadly perished in the sweltering heat, but it's not their remains that earned the Skeleton Coast its name. That came from the vast number of animal carcasses that washed up on the shore as a result of the whaling operations and seal hunting that were once common in the area. The harsh desert conditions have meant that the bones haven't decomposed, and so can still be found alongside the human skeletons.



Above
Elephants migrate along the desert's river channels in search of food and water

Stranded on land
The wreck can now be found around 500m from the ocean, surrounded by desert sand.

Exposed to the elements
The wreck is being slowly eroded by the wind, sand and salty sea air.

© Almay; Thinkstock

What is the life cycle of a frog?

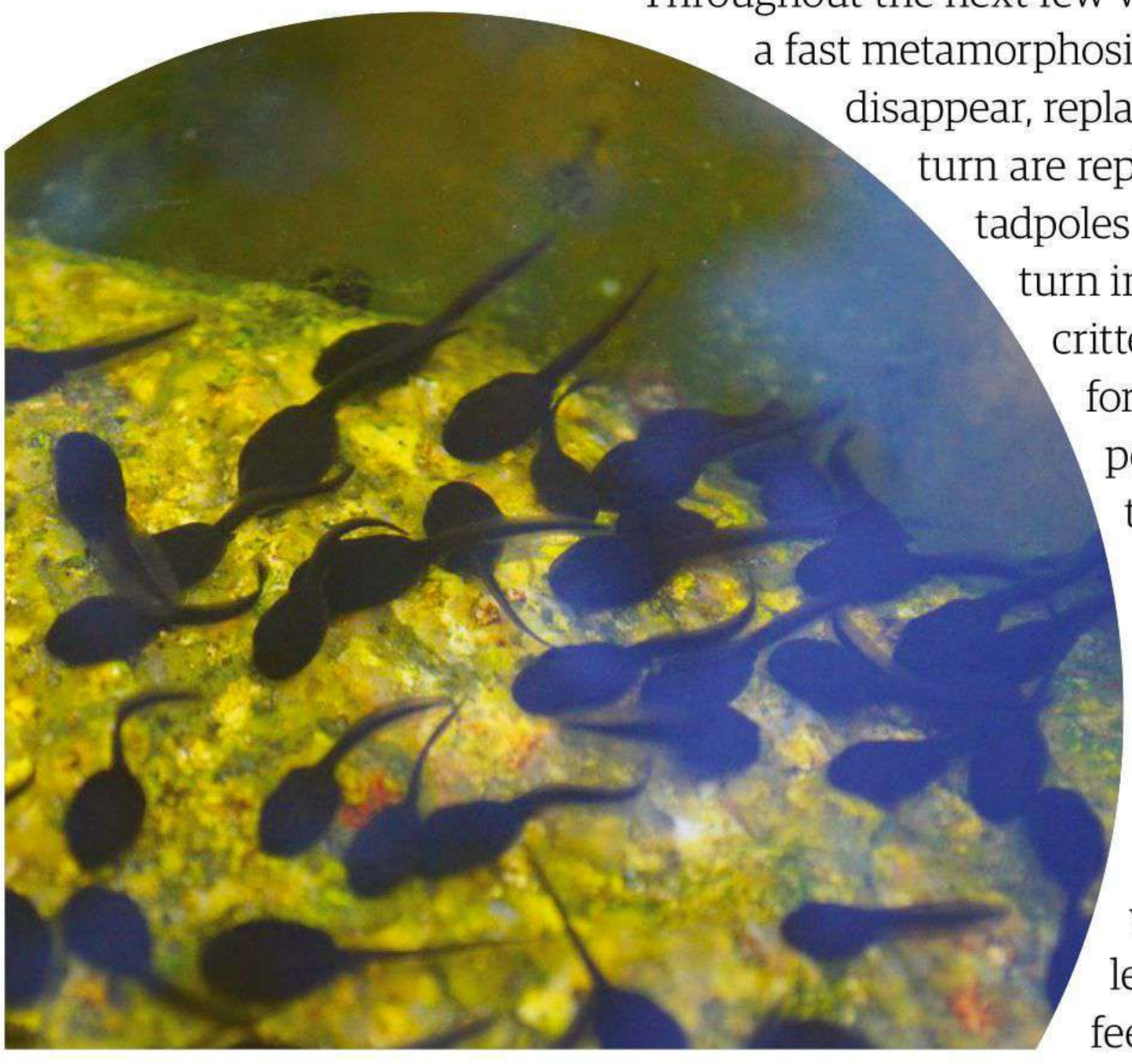
Discover how a cluster of cells transforms into a hopping, croaking amphibian

The cycle begins when frogs come together to mate. The male holds the female in a position known as amplexus and fertilises her eggs as they are laid. A female frog can lay a clutch of around 3,000 to 6,000 eggs.

Within each jelly-like sphere is a black dot – the developing tadpole. The embryos feed off the surrounding jelly as they grow, and then once they have developed rudimentary gills and a tail after about a week or a month (depending on the species), tadpoles hatch. The hatchlings feed on the rest of the frogspawn jelly mass, as well as any algae that has grown on it.

Throughout the next few weeks the tadpoles undergo a fast metamorphosis. First their external gills disappear, replaced by internal gills, which in turn are replaced as lungs develop. The tadpoles also grow legs while they turn into froglets – strange round critters that resemble their adult form, while still retaining their powerful tail. The front legs are the last to develop, and the tadpole's tail is shortened as it is reabsorbed into the body.

The little frog is now a miniature version of its parents at just one centimetre in length. After around 16 weeks of development it can leave the water, breathe air and feed on bugs and insects.



Below
Tadpoles are often seen in large groups, that are sometimes called 'clouds'

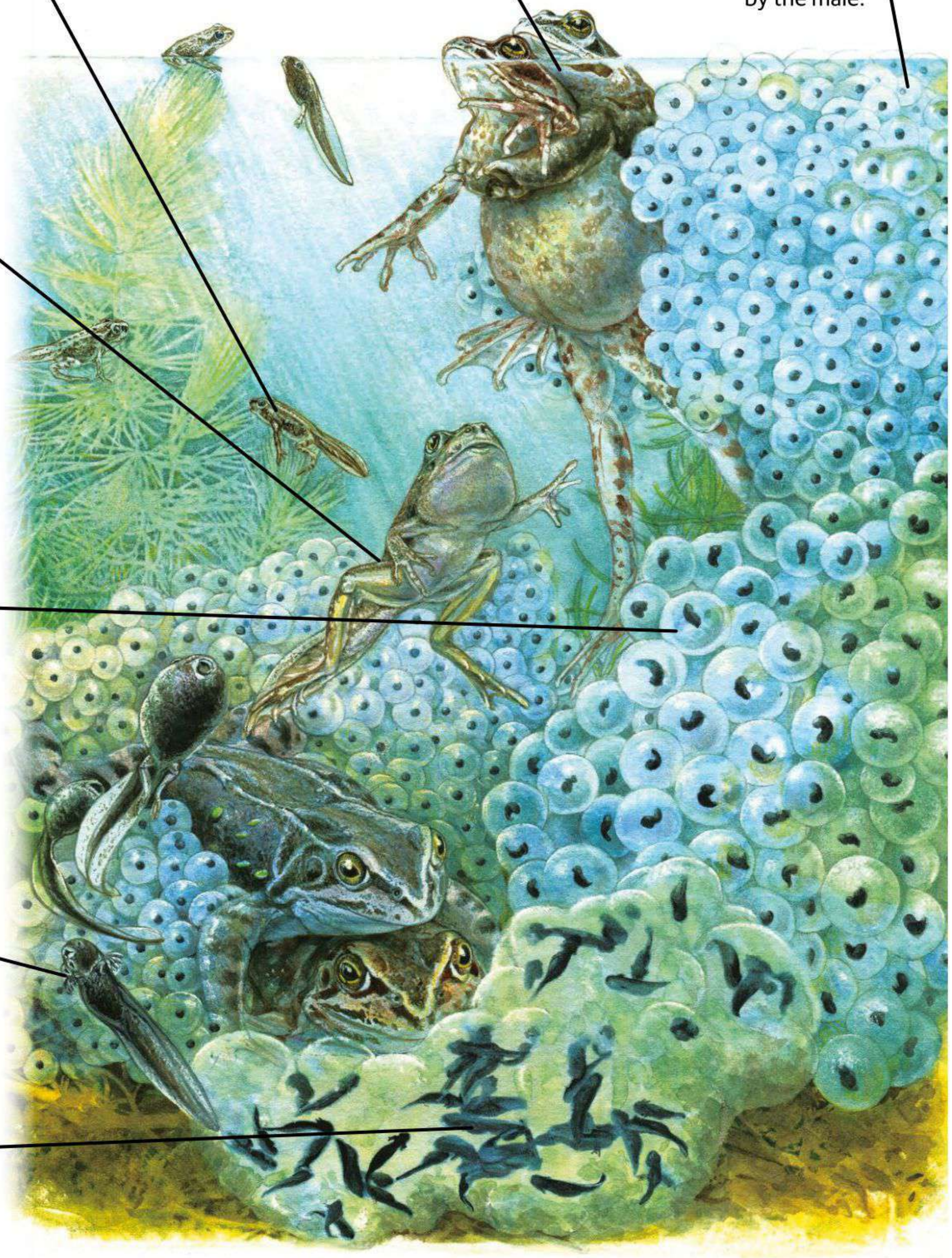
From frogspawn to full-grown

Check out how frogs are born and develop

Metamorphosis
In several stages, the tadpole grows adult eyes and front legs and loses its tail.

Amplexus
The male positions himself behind his mate and holds her firmly with his front legs.

Spawning
During spawning the female lays her eggs, which are then fertilised by the male.



Adult frogs
The young frog continues growing once it leaves the water. After around three years it is ready to reproduce.

Eggs
Frogspawn is buoyant, and large clumps of the gelatinous egg mass can normally be seen floating on a pond's surface.

Froglets
As the tadpole grows, it develops a strong tail as well as powerful back legs.

Tadpole
After a few weeks, the small tadpoles hatch with external gills and long tails.

How does a venus flytrap work?

Insects don't stand a chance when they land on this killer plant

The carnivorous Venus flytrap sports a menacing-looking mechanism. The spiked, collapsible leaf is laced with drops of sweet nectar to lure in its prey.

When a bug lands, it touches the sensitive trigger hairs on the Venus flytrap's leaves. According to the latest theory, touching one hair does nothing, but touching two causes the trap to snap closed. When the fly struggles, it's likely to trigger three hairs, which readies the plant's cells for digestion, and touching five hairs starts the release of digestive enzymes. The plant can even adjust the amount of digestive fluid produced, depending on how large the prey is.

When an insect lands on the trap and triggers the hairs, this tension is released and the leaves close in a fraction of a second. The large guard hairs fold together, depriving the insect of any means of escape. The digestive fluids break down the soft parts of the prey and absorb the nutrients. Five to 12 days after capture, the trap will reopen to expel the waste exoskeleton.

Marginal spines
These protrusions of the leaf prevent the prey from escaping the trap.

Trigger bristles
When a fly lands, sensitive hairs on the inside of the leaf trigger the trap.

Digestive glands
Spots inside the leaf secrete digestive fluids and absorb nutrients from the prey.

Nectar
The leaves secrete a sweet nectar to lure in its unsuspecting prey, typically insects and spiders.

What are killer plants?

Not satisfied with making food through photosynthesis, these five carnivorous plants capture, kill and eat living prey

Drosera

There are over 100 species of drosera, which are commonly known as 'sundews' as they appear to be constantly covered in dew. These tiny droplets are actually sticky enzymes that trap and start to digest any prey as soon as it lands on the plants' leaves.

Pinguicula

This plant catches prey using sticky leaves. The tacky substance is actually full of digestive enzymes, which break down the insects once they become trapped. When winter arrives, some species of pinguicula become quite dormant and cease their carnivorous activities.

Nepenthes

These plants lure insects, sometimes even rats, into their cup-like pitchers with an attractive scent. Once trapped, the prey drowns in the liquid within the pitcher and is broken down by digestive juices, allowing the plant to absorb the vital nutrients it needs to survive.

Sarracenia

Like Nepenthes, sarracenia is a pitcher plant. Insects are attracted to its colour and sweet scent. As they land at the edge of the pitcher, they often fall in, since the edge is very slippery. Once inside, there is no escape due to the smooth, steep sides of the pitcher.

Venus flytrap

When an insect or arachnid steps on more than one of the tiny hairs of the plant's jaws, it triggers a violent reaction. The hinged mouth snaps down, trapping the prey inside the plant. Digestive enzymes are secreted and it can be several days until the plant re-opens.

What is soil made of?

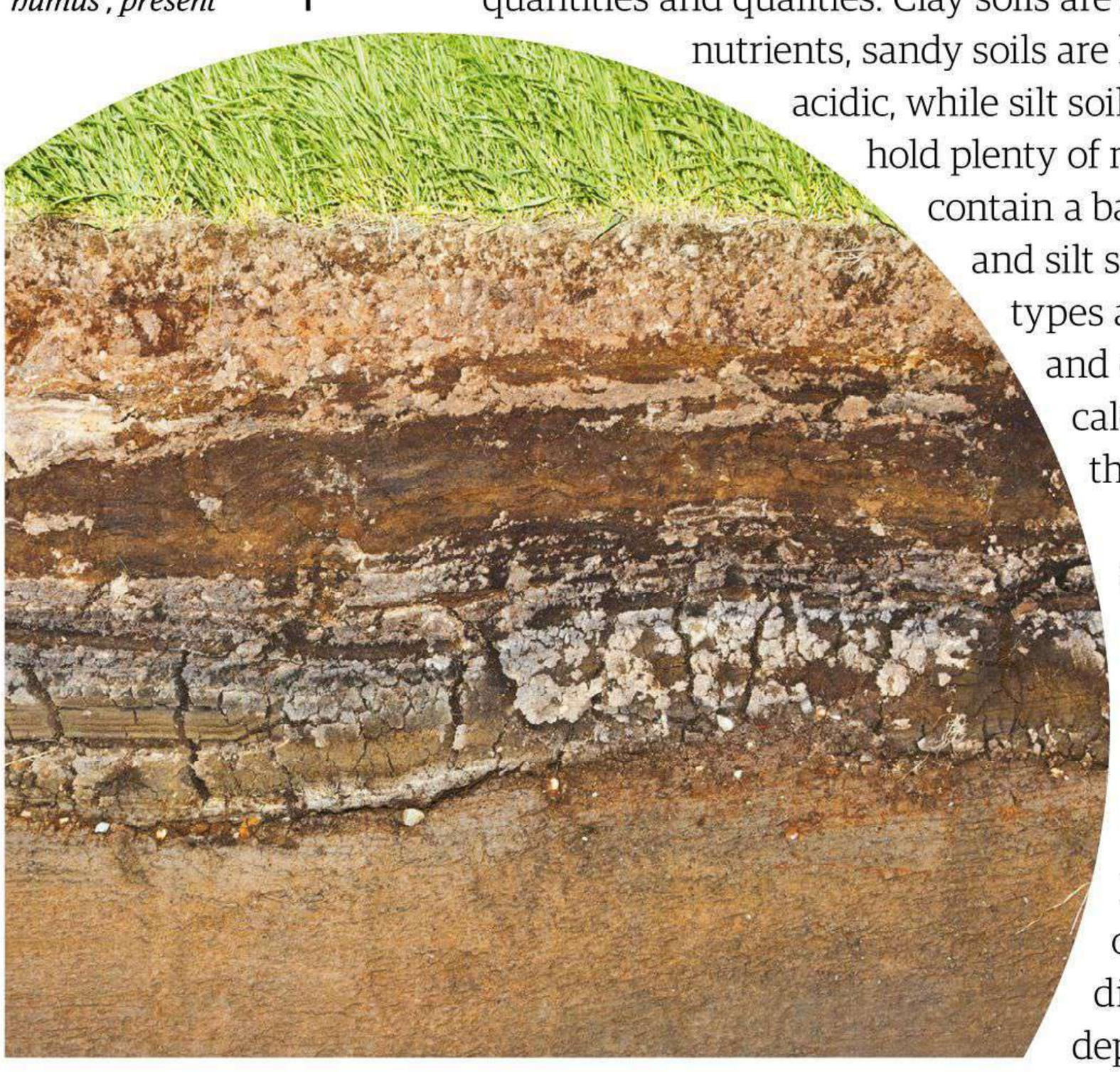
The ingredients that form one of Earth's most important natural resources

In its simplest form, soil is a gritty mixture of ground-up minerals and decaying organic matter, such as leaf litter from the forest canopy. These raw ingredients are then all completely mixed and churned together by the bugs and worms that live within.

The broken-up rocks that make up soil can come from the bedrock that lies deep below, or from other sources, where rocks, rubble and more soil is transported by forces such as rivers or glaciers.

There are six major types of soil, each with different mineral quantities and qualities. Clay soils are dense but high in nutrients, sandy soils are light, dry and relatively acidic, while silt soils are very fertile and hold plenty of moisture. Loam soils contain a balance of clay, sandy and silt soil types, while peat soil types are full of organic matter and chalky soils contain calcium carbonate and are therefore very alkaline.

Many different types of soil will constantly continue to build up in layers in any given spot over time, making what is known as soil horizons. These layers usually consist of organic matter in various different stages of decay, depending on the locality.



Below
Soil appears darker when there is more organic matter, or 'humus', present

How does Saharan dust make its way around the world?

Discover how weather conditions can whip up sand from the Sahara Desert and carry it around the world

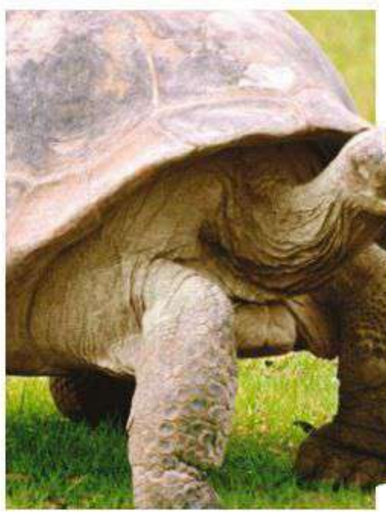
Below
Hurricane Ophelia transported dust from the Sahara

Saharan dust is a mixture of dust and sand from the Sahara Desert. When very strong winds pass over the desert, this mixture blows up into the sky to form clouds, which can reach astonishingly high altitudes. Winds in the upper part of the atmosphere then transport these dust clouds, also known as the Saharan Air Layer, towards the UK.

The particles are capable of travelling thousands of kilometres on these dust-laden winds, crossing land and entire oceans where they even become visible on other continents.

What are the differences between turtles and tortoises?

They certainly look alike, but just how similar are these creatures?



Above
Tortoises have both an endoskeleton and an exoskeleton

An obvious distinction between tortoises and turtles is where they live: tortoises are land dwellers, whereas most turtles reside in or around water. A turtle's shell is lighter and flatter to prevent it from sinking and more streamlined to help it swim, while a tortoise's shell is larger and heavier and shaped like a dome to protect it from predators. Turtles also have webbed feet to aid swimming, while tortoises possess stubby feet for walking across various terrains.

What is Canada's Spotted Lake?

Nestled in a mountainous, forested landscape is a masterpiece of nature

Near the town of Osoyoos, in Canada's British Columbia, lies a lake covered in large, round patches that look as if they have been drawn on by hand. This amazing natural phenomenon appears every summer when scorching temperatures cause the shallow water of the lake to evaporate.

Covering an area of around 16 hectares, the patches that give Spotted Lake its name are actually pools of rich minerals, including calcium, sodium sulphates and magnesium sulphate, as well as traces of silver and titanium. Hues of green and blue decorate the landscape, and throughout the summer the spots change colour and shape as the minerals adapt to further evaporation. When the fresh water disappears, the bed of the lake is exposed, providing natural walkways through the mineral-rich pools.

However, walking through the Spotted Lake pools isn't a possibility for visitors, as it's owned by the Okanagan Nation. To the native community of the Okanagan Valley, the lake is known as 'Kliluk' and holds special spiritual and historical significance. It was bought back from a private owner in 2001 so that it could be protected from development.

Right
There are 365 circles in Spotted Lake, one for every day of the year!

Why are the tropics hotter than the equator?

Complex weather patterns are behind the marked difference in temperature

Above
Some of the hottest places on Earth are in subtropical regions, including Death Valley in the US and the Lut desert in Iran

The equator is the latitude that falls at the point on Earth that is an equal distance from the North Pole and the South Pole, making it zero degrees latitude. The tropics surround the equator; the Tropic of Cancer is north of the equator, whereas the Tropic of Capricorn lies to the south. Sunlight hitting the equator generates rising air currents, contributing to cloud cover and thunderstorms which reduce the air temperature by several degrees. At the subtropics, around 20° to 40° above and below the equator, the atmosphere is more stable, so there is little cloud cover. This creates hotter and drier climates than those experienced at the equator.

What is the life cycle of a pine tree?

How exactly do these hardy giants grow from the tiniest of beginnings?

Vast forests of pine trees can be found in many different regions, from the snowy mountains of North America to the open plains of Europe. These hardy evergreen trees can grow in environments that many others can't, favouring acidic or sandy soils and rocky regions at high altitudes.

When exposed to plenty of sunlight, pines can grow up to a towering 80 metres (262 feet) and live for hundreds of years. One bristlecone pine in California is thought to be 5,000 years old, making it one of the oldest trees in the world, but most are cut down long before they reach this ripe old age.

Although pines are native to temperate regions in the Northern Hemisphere, some species have been introduced to southern continents as a valuable source of timber, an industry worth billions of pounds. The young pines that don't go on to become fence panels and furniture usually end up as Christmas trees in homes across the world. Over 77 million pines are planted for this purpose each year, and take six to eight years to reach optimum Christmas tree size. However, when left to their own devices, pine trees grow to have long, slender trunks – almost unrecognisable as the same trees we decorate with tinsel and fairy lights – and use pine cones to reproduce. Each tree uses both male and female structures to create the next generation.

Below
Squirrels help to disperse pine seeds when they bury the cones as a winter food supply

From cone to tree

Follow the full development of an adult pine tree

1 Male and female

Mature pine trees are monoecious, meaning that they have both male and female reproductive structures which are called strobili.

2 Male strobili

The male strobili form in the bottom part of the tree, and contain microsporocytes that develop into pollen.

3 Pollen released

In spring, the male strobili release their pollen, which then falls to the ground.

4 Female strobili

The pollen is carried by the wind up to the female strobili, which grow at the end of each of the tree's branches.

5 Pollination

Once the pollen lands on the female strobili, it finds its way into the ovules to fertilise the egg cells.

6 Fertilisation

It takes about a year for fertilisation to occur, in which time the strobili develop into woody pine cones.

7 Pine cone

Once matured, the woody cones open up, exposing the seeds that sit at the end of each of their scales.

8 Germination

The seeds are dispersed by animals or by the wind, and under the right conditions, germinate and then develop into seedlings.

Do bumblebees make honey?

Do bumblebees produce honey like their honeybee relatives?

Above
Bumblebees are found to live in small nests, unlike the large, organised hives of their honey-making cousins

The bumblebee is bigger, rounder and fuzzier than the wasp-like honeybee. Both bee types are crucial in the pollination of plants and crops and they both gather nectar to produce honey. However, the substance made by honeybees is produced in large volumes via a rather long-winded method, whereas bumblebees produce a more simplified 'honey' in small quantities. This is actually nectar that the queen bumblebee deposits into wax pots. She uses this to provide food for herself and her young. It is honey in the sense that it's produced by bumblebees from nectar, but it probably won't taste that good on your toast!

What are woodlice?

There is far more to these little armoured critters than initially meets the eye

Below
Woodlice are so tolerant to heavy metals that they can actually be used as pollution bioindicators

The next time you move something in the garden and see a woodlouse scuttling out from underneath, remember that these little guys are in fact isopod crustaceans! They're more closely related to crabs and lobsters than ants and spiders. Although they're landlubbers, one trait woodlice share with their aquatic cousins is that they use gills to breathe.

They like to live in moist, dark places where there's plenty of decaying material to eat. Their bodies are made up of armoured segments of an exoskeleton that allow them to roll up into balls when threatened (hence the nickname 'pill bug'). As they grow, woodlice need to shed their skin. This happens in two separate stages; the back sheds first, followed by the front, which is why a woodlouse may sport two different colours.

© Wiki

Shuffling on 14 legs, woodlice have two 'uropods' at the back of their bodies. These are for navigation, and some species use them to secrete defensive substances. Uropods are also used for drinking; the louse sucks up water through the tubes into its anus. Any waste is excreted as ammonia gas through pores in the exoskeleton, woodlice don't ever pee!

Do penguins get cold feet?

Discover whether penguin also get frozen feet

Yes. Penguins do actually get cold get cold feet, however unlike humans, they are still able to continue functioning due to the way their feet are operated. The tendons that are attached to their ankle and toe bones pass through the muscles that are in the warmer parts of their bodies. Though their feet may become cold, the muscles that operate them are still at a normal body temperature. When the external temperature drops significantly, feathers and the fat layer of the body automatically start to protect the feet, which are not allowed to go below freezing. The penguins blood flow also automatically adjusts to ensure that this doesn't happen and the penguin is able to continue functioning.

Below
Penguins do get cold feet, but are still able to use them

Why do chickens have combs?

What is that fleshy thing on top of a chickens head?

Chicken combs actually help keep the birds cool. Chickens can't sweat, so when they overheat, blood rushes into the cooler combs on the tops of their heads. Combs are also a good indicator of a chicken's health; a bright red comb is normal, while a pale or darker comb may mean illness. Comb colour, shape and size vary by breed, but males have larger combs than females. They also play a part in mating; a healthy comb is more attractive and signals that a chicken is ready to mate.

Right
This rooster's brilliant red comb keeps him cool and shows that he's fighting fit

How many species have humans driven to extinction?

Find out just how much devastation humans have wrought

Below
Badgers and foxes are the largest carnivores left in the UK

It's impossible to give a definitive numerical answer, but it's likely to be far higher than the impact of any other species. No other animal changes its environment as much as we do, and our activities have knock-on effects that impact thousands of other species. According to a paper published in 2014, extinction rates are 1,000 times higher than they would be if we weren't around. Take a look at the UK, for example. Thousands of years ago, the land was covered in thick forest, and bears, wolves, lynxes and even woolly mammoths roamed the land. We stripped out the trees, hunted the animals, and turned natural landscapes into concrete jungles.

Are cats evolving thumbs?

Could we soon be shaking hands with our pets?

Cats usually have five toes on their front paws and four on the back paws. However, some are born with up to eight toes on one or more of their feet. This genetic mutation, called polydactyly, is common in cats. Although these extra toes can allow felines to get a better grip with their front paws, the toes aren't opposable, so there's no evidence that polydactyly means cats are evolving thumbs. The Guinness World Record holder for most toes on a cat is seven on each foot for a total of 28, held by Jake of Ontario, Canada.

Right
A cat's extra toes are cute, but they aren't leading to opposable thumbs

©Thinkstock, Pixabay

What's the difference between cocoa and cacao?

Which substance is used to make your favourite treats?

Below
Cacao beans are extracted from the pods of the Theobroma cacao tree

Both come from the same source, cacao beans, which are the seeds of the Theobroma cacao tree. But they differ in the way they are processed. Once the beans have been harvested, they're left to ferment in a low heat. This causes cacao butter, the white fatty substance coating the beans, to melt away. The beans are dried and the shells removed, leaving raw cacao nibs, which can be ground into cacao powder. Cacao nibs can also be roasted at high temperatures and ground into a liquid called cocoa mass. This is compressed to extract cocoa butter and then either pulverised into cocoa powder or used with the cocoa butter to make chocolate bars. Roasting cacao brings out the sweetness and characteristic chocolate flavour of cocoa, but it can also reduce its nutritional value.

How do bats sleep upside down without falling?

How do they manage to stay upside down?

Above
The greater horseshoe bat always hibernates in a cave

Bats' legs are rotated 180 degrees so their knees appear backwards to us, and special tendons in their toes stay flexed so that they don't have to use up any energy to hang on – they only need to let go to fly. In fact, those tendons are so strong that bats continue to hang after they die. As bats are generally very small, hanging upside down doesn't affect their blood flow the way it does ours. They don't get dizzy, and their ability to hang upside down means that bats can roost in places no other animal can.

Is the killer whale a whale or a dolphin?

How misleading is the creature's name?

Killer whales, also known as orcas, are the largest members of the dolphin family. Dolphins and whales are however closely related, belonging to the order Cetacea, which also includes porpoises. Sailors named orcas 'whale killers' after seeing them attack whales, and the name was later inverted to 'killer whales'. Many different populations of killer whale exist, exhibiting different morphology, behaviour and diet. Some of these populations have not interbred with other orca populations for hundreds of thousands of years and so could be considered separate species or sub-species.

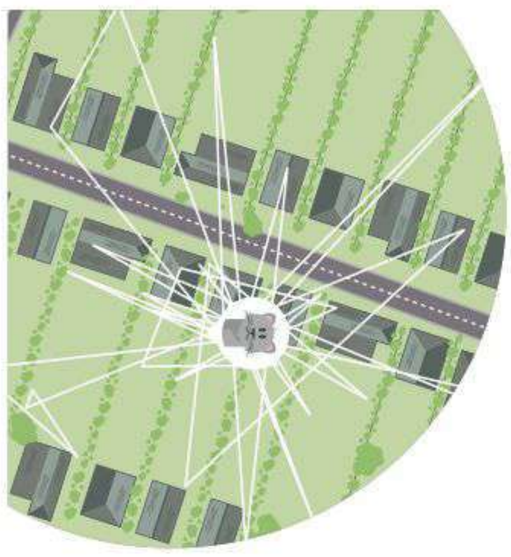
Below
Along with 31 other species, killer whales are part of Delphinidae, the dolphin family

Do dock leaves really soothe nettle stings?

Discover the truth behind a classic remedy

When you brush against a stinging nettle, tiny hairs on the leaf pierce your skin, injecting you with various chemicals that cause a painful stinging sensation. When this occurs, many people will instantly look for a nearby dock leaf, claiming that rubbing it on the affected area soothes the pain. However, no one quite knows why it seems to help. Some claim it is because dock leaf sap is alkaline, so neutralises the formic acid found in nettle hairs, but the sap is in fact acidic too. Others claim that the leaves contain a natural antihistamine that works against the pain-inducing histamine of stinging nettles, but there is no scientific evidence for this. Therefore, the common consensus is that the leaves merely have a placebo effect.

Above
There is no scientific evidence that dock leaves contain sting-soothing chemicals



Left
We thought our cat was a lazy old mog, but her GPS tracker shows she is pretty active

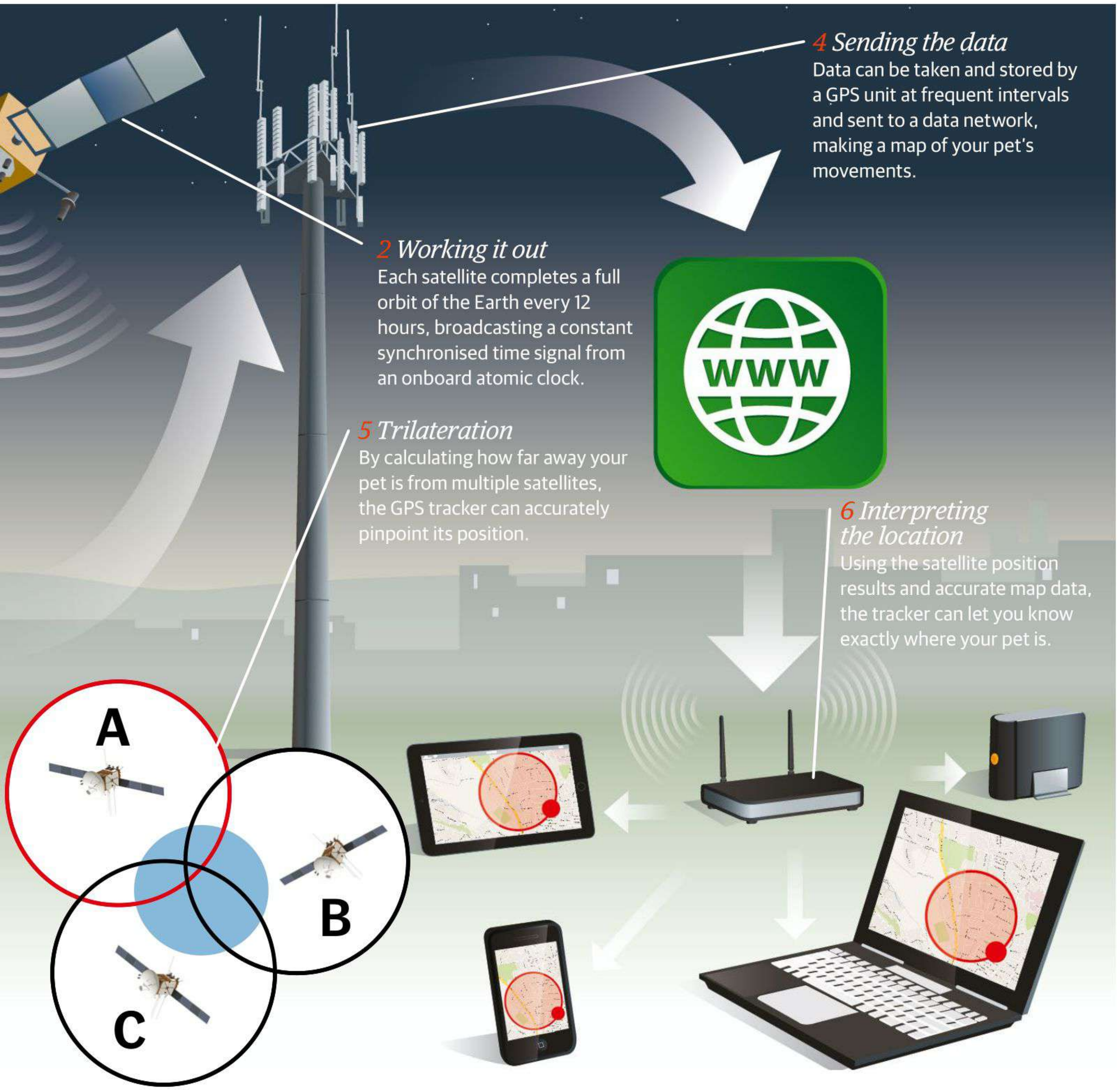
How does GPS work?

The hardware that is in the sky explained

Right now, there are 31 satellites circling Earth in what is known as the Global Positioning System (GPS) Constellation, feeding back information to millions of GPS devices. Whether you're searching for nearby car parks on your sat nav or tracking down a lost pet, the technology works in the same way.

A GPS receiver in your pet tracker locates at least three of these satellites to calculate exactly where on the planet it is. To do this, the receiver intercepts signals from the satellites and calculates how long it took them to arrive. Because the signals always travel at the speed of light, it is even possible to work out the distances between each of the satellites and your furry friend.

The exact position of the receiver can be pinpointed via a process called trilateration. Say your pet's tracker receives signals from three satellites. It can calculate how far away each satellite is, but not which direction the individual signals came from. For example, if one signal is calculated to come from 20,000 kilometres away, the receiver could lie anywhere on an imaginary sphere with a 20,000-kilometre



radius surrounding that particular satellite. This is actually why multiple satellites are required in GPS; finding where three or more of these spheres from different satellites intersect enables the receiver to figure out exactly where your pet is. The more satellite signals the tracker is able to pick up, the more accurate the ultimate position will be.

As tech become more complex, GPS receivers are able to store more detailed maps. So, if your pet is wearing a tracking device, you will be able to locate specific streets, fields or buildings that it walks past.

What is a cyborg plant?

Discover how to turn a living rose into an electric circuit

If you struggle to keep your houseplants alive, then the idea of a shrub that can alert you when it needs watering would certainly be appealing. Thanks to researchers in Sweden, that idea is much closer to becoming reality.

The team from Linköping University has created the very first electronic plant, which they say opens up the possibility of being able to read and regulate plant growth by measuring the concentration of their various molecules, as well as making use of the energy they produce through photosynthesis in a fuel cell.

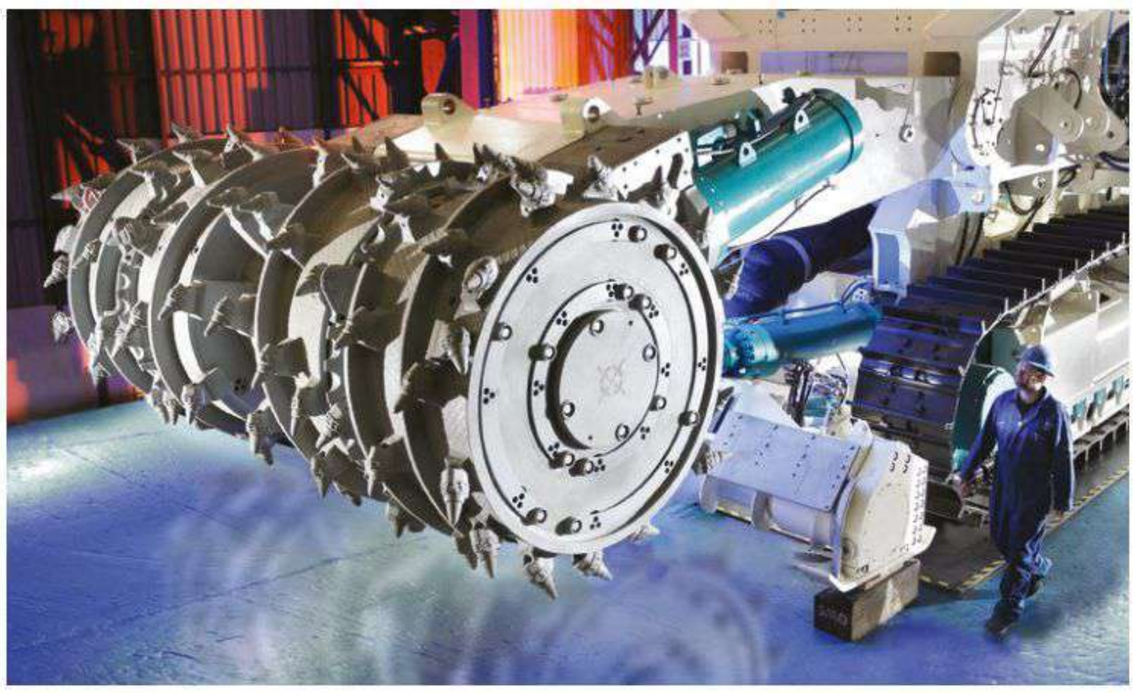
To create their cyborg rose bush, the researchers used a synthetic polymer called PEDOT-S, which was drawn up through the plant's stem by capillary action – the same process plants use to absorb water. Once inside this channel, the polymer converted itself into a thin film that could conduct electrical signals, but still left enough room for water and nutrients to pass through and keep the plant alive. By placing an electrode at each end of the conductive film, the team was then able to create a transistor: an electronic switch that completed the circuit.

Below
The researchers have been able to create electrochemical cells in plants, which can change the colour of the leaves

How do seabed mining robots work?

The deep-sea machines that extract valuable minerals from the ocean floor

Below
Computers contain fans and heatsinks to remove excess heat and keep them cool

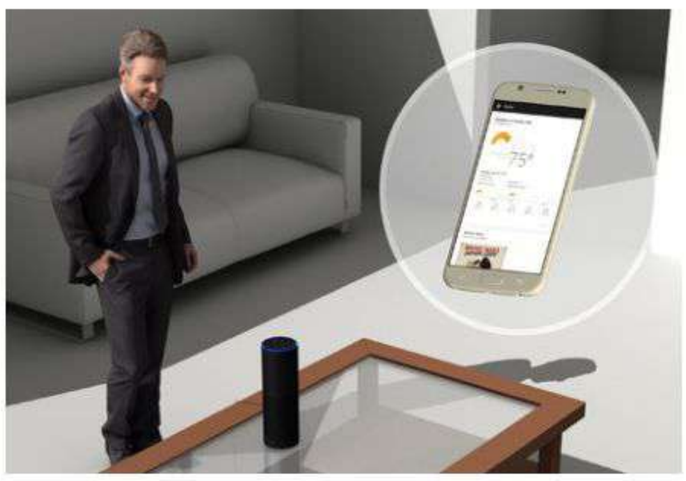


Spewing hot, chemical-rich fluids from beneath the seafloor, hydrothermal vents are a valuable source of minerals, including copper, nickel, silver and gold. However, as they lie hundreds of metres below the ocean surface, getting at these sought-after deposits is a tricky business. This is why Toronto-based mining company Nautilus Minerals is planning to deploy a team of robots, or Seafloor Production Tools, to do all the hard work for them.

First, the Auxiliary Cutter will carve benches into the seafloor's rough terrain so the other machines have a flat area to work on. The Bulk Cutter will then slice away material from the seabed using spiked rotating drums, leaving it for a Collecting Machine to draw in as seawater slurry. This machine will push the slurry of crushed rock and water through a pipe to the Riser and Lifting System, which will then pump it up to a Production Support Vessel on the surface. Here, the slurry will be filtered to extract the minerals, and the leftover seawater will be pumped back to the seafloor.

How does Alexa work?

Inside Amazon's incredible digital assistant, set to revolutionise homes forever



The Alexa effect

The process behind Alexa's amazing ability to get things done

1 Say 'Alexa'
This is all it takes to wake up the Echo unit and get Alexa to start listening.

2 Recording
Echo's seven far-reaching microphones record your voice from anywhere in the room.

3 Alexa Voice Service
Using the internet, the recording is sent to Amazon's cloud, which analyses the request.

4 Skills in action
The specific 'skill' that you've requested is actioned, and the relevant data is sent back to your Echo.

5 Alexa speaks
Alexa then tells you that the request is completed, and you will then hear the music or information over the speakers.

6 Alexa App
The app will also flash up on your phone or tablet to show you any visual data that you've asked for.

Amazon's virtual personal assistant, Alexa, is intended to rival even the most competent of human aides. Enabled devices, such as the Echo unit, include a series of speakers and sensors that work together, centrally controlled by Alexa. This is furnished with seven microphones and uses beamforming technology to hear you from wherever you are in the room. Users simply need to say 'Alexa' followed by their request and the unit closest will then respond. You'll hear Alexa's voice confirm it or give you the information before completing the task.

Meet the Alexa family

The cutting-edge tech that is changing home entertainment

1 Tap
An Alexa-enabled portable Bluetooth speaker, Tap streams your music from your phone or tablet and links with Alexa when connected to Wi-Fi.

2 Fire TV
Amazon's Fire TV stick plugs into a TV to stream digital media. A voice remote has a button that you can press to speak to Alexa.

3 Echo
An interactive speaker and smart home hub, Echo connects with Alexa to play music, news and provide information.

4 Echo Dot
A versatile speaker, like Echo, but newer and designed to hook up Alexa for use with your existing sound system.

© Illustration by Adrian Mann

What is inside a loud speaker?

Learn how speakers make noise

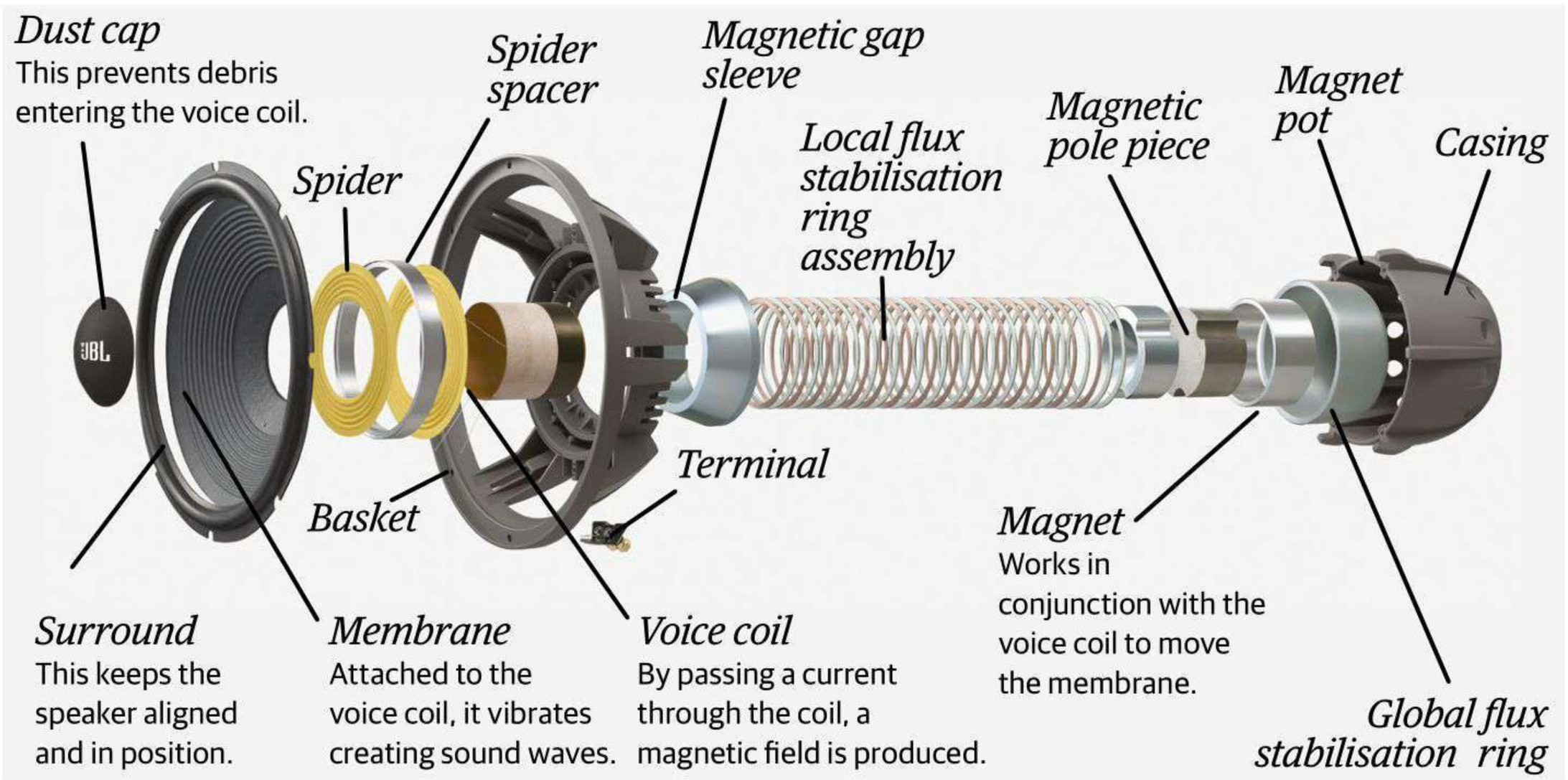
Below
All speakers great and small use electromagnet mechanisms to pump out the sound waves

In their simplest form, speakers use an electromagnet to move a cone-shaped membrane that vibrates to make noise. Inside the speaker, the mobile electromagnet is placed in front of a fixed, normal magnet. As electricity passes through the coil of the electromagnet, the direction of the magnetic field rapidly changes. This causes the electromagnet to continually be repelled by and attracted to the normal magnet, moving the cone-shaped membrane back and forth. The membrane pushes and pulls the surrounding air molecules, creating waves of sound that reach your ears.

The pitch of the sound is governed by the frequency of the vibrations, while the volume is controlled by the amplitude, or height, of the sound waves. Some types of speakers use multiple cones of various sizes to replicate the different frequencies in a piece of music.

Inside a Harman speaker

The key components that allow you to listen to music loud and clear



How does time-lapse photography work?

Discover the ways to watch the world go by in a flash

By taking a series of photographs in defined intervals, time-lapse photography speeds up time so you can see an entire day pass by in a video of only a few seconds.

The general rule for this technique is the faster the scene is moving, the shorter the intervals between each image and visa versa. To determine the length of the final clip a little maths is needed. In order to produce a video clip of one minute with image intervals of three seconds at 25 frames per second, you would need to take 1,500 pictures over a period of one hour and fifteen minutes. Automated 'intervalometers' snap a new image at the set interval, meaning you don't have to stand there clicking every couple of seconds.

Below
Time-lapse photography can show an entire day in one photograph

What are noise-cancelling headphones?

How does this audio technology reduce ambient sound?

Below
Active noise-cancelling headphones can block out up to 70 per cent of background noise

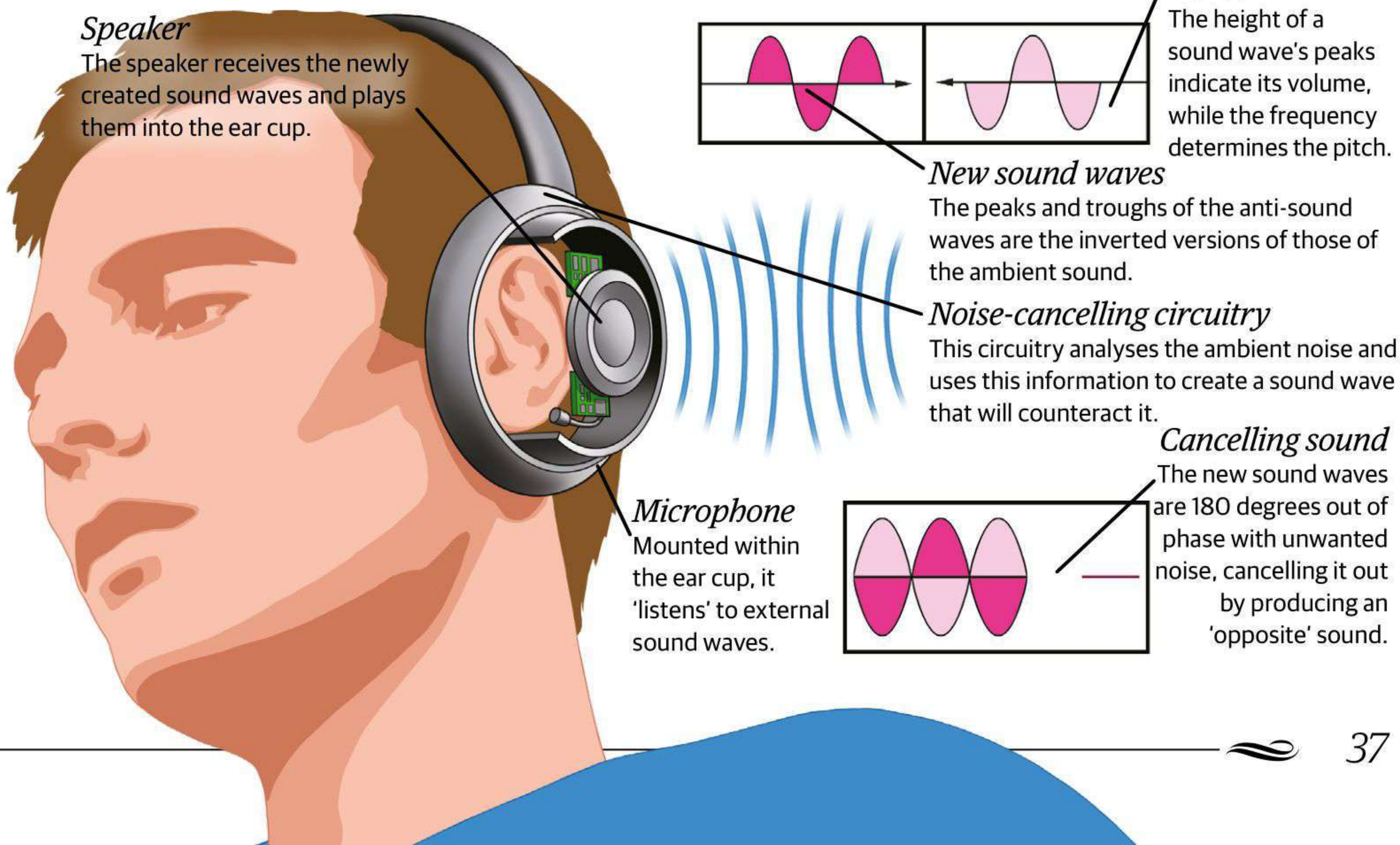
© Thinkstock

Noise-cancelling headphones can reduce ambient sound around you. Active noise-cancelling headphones use special materials, but go one step further and create their own sound waves too. Inside the earpiece is a small microphone that detects ambient sound and feeds it to a digital processor, which analyses the sound wave's composition. It then creates a sound wave opposite of the one it analysed. This 'anti-sound' wave has the same sized peaks and troughs as the background noise, but they are inverted.

These anti-sound waves are then played back from a small speaker in the ear cup, actively blocking the ambient sound waves through a phenomenon known as destructive interference. The sum of these two waves adds to zero, resulting in minimal external sound.

Active noise-cancelling

How does the system hear, analyse and block unwanted sound?



How do multicopters take off?

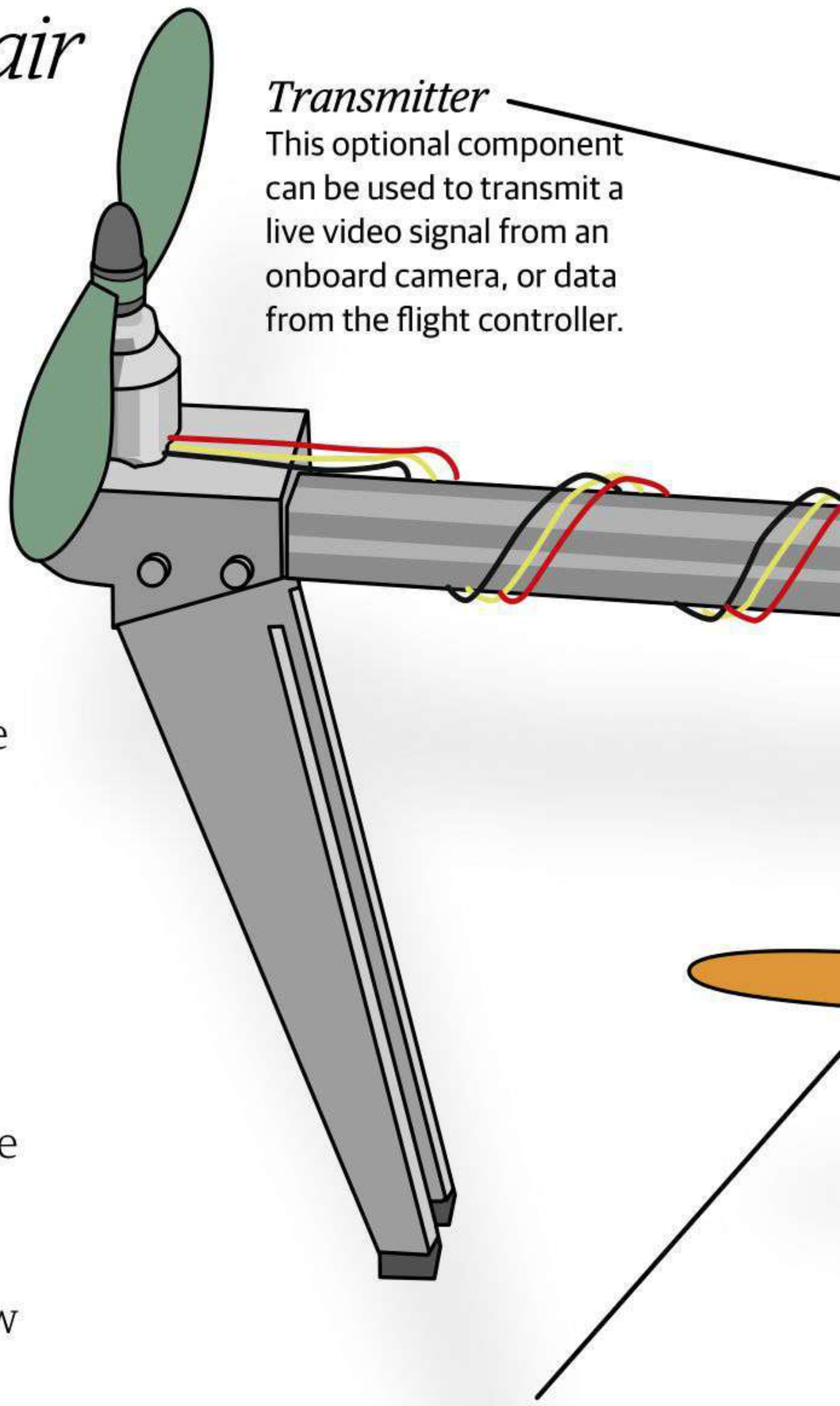
The science and tech that gets commercial drones into the air

Drones come in all shapes and sizes, from the mammoth machines used by the military, to the toys you fly in your back garden. However, while they are all operated remotely, the methods they use to get into the air can differ greatly.

Those that take off like normal airplanes use engines or vertical propellers to create thrust, propelling them forwards and causing air to flow rapidly over the wings. The curved shape of the wings then deflect air, creating a difference in pressure above and below. As the air pressure below the wing is higher, this generates lift to push the drone upwards.

VTOL (Vertical Take Off and Landing) drones however, don't need a runway for take-off. They use engines or horizontal propellers to direct thrust downwards, thereby creating lift that gets them off the ground. This is the method favoured by commercial drones, which often come in the form of multicopters.

These miniature flying machines feature four or more horizontal propellers, which create plenty of thrust to allow them to hover above the ground. The propellers rotate in opposing directions to avoid spinning the multicopter out of control. They can also be used to change its direction by increasing or decreasing the speed at which certain propellers rotate.



Transmitter
This optional component can be used to transmit a live video signal from an onboard camera, or data from the flight controller.

Electronic speed control
The ESC takes power from the battery and sends it to the motors according to the flight controller's instructions.

The anatomy of a drone

Explore the components that make multicopter flight possible

Above
Multicopters typically have an even numbers of propellers; quadcopters have four.

Propellers
An even number of propellers help to generate thrust and lift, and keep the drone steady in the air.

Flight controller
A mini computer works out how much power to send each motor based on the pilot's instructions and data from altitude sensors.

Brushless motors
These motors change the speed and rotation of each propeller to keep the drone upright and moving in the desired direction.

Radio receiver
This device receives radio signals from the pilot's remote controller, which are then sent on to the flight controller.

Gimbal controller
This device detects the movement of the drone and controls the gimbal motors to keep the camera steady.

Camera mount
A camera, such as a GoPro, can be mounted onto the drone to record or stream live footage from the air.

Gimbal motors
The position of the camera is adjusted automatically, to keep it steady, and manually, to change the angle of view.

What is drone racing?

The new high-octane sport putting quadcopter pilots to the test

Swooping through the air at 130 kilometres per hour, flying through narrow hallways and veering around tight corners, this isn't your average quadcopter flight. In the world of professional drone racing, pilots' skills are always pushed to the limits as they manoeuvre their flying machines around some of the toughest obstacle courses on Earth.

One of the biggest tournaments of this kind is the Drone Racing League (DRL), a global competition that sees the world's top drone pilots compete for prize money and, more importantly, world champion status. This is essentially a Formula 1 competition for drones and it features a series of races held in enormous sports stadiums and derelict buildings around the world. All of the competing pilots fly the same model of drone, the DRL Racer 2, in order to test their skills on a level playing field. In each race, they score points by passing checkpoints and finishing the course within the allotted time, and at the end of the heats the pilot with the most points is crowned the winner.

Below
All DRL pilots have a fleet of DRL Racer 2 drones to use for each race

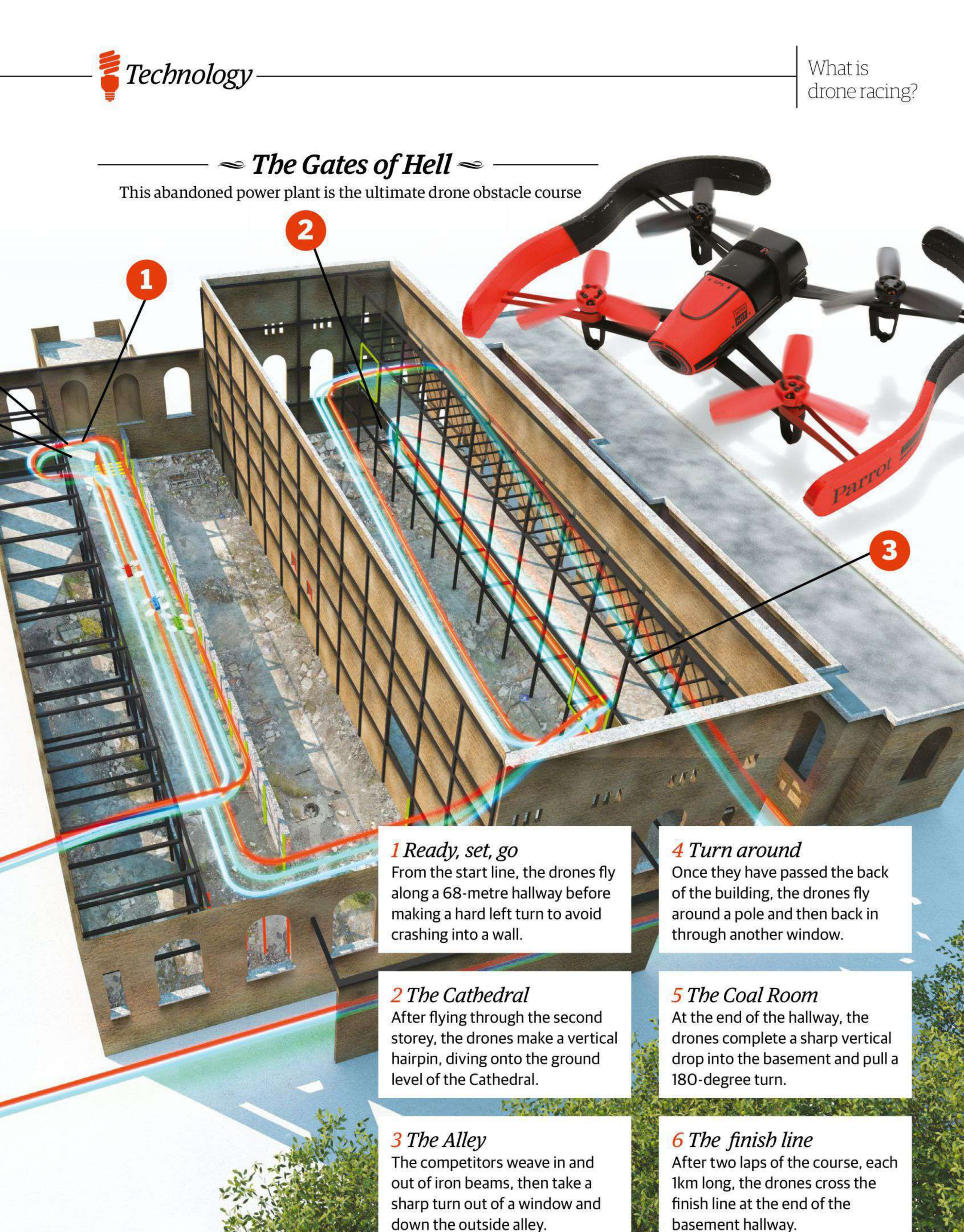
Built for speed

The custom-made DRL Racer 2 drone is piloted using a remote control, which sends signals to the craft via radio link. DRL's patented new radio technology ensures reception is never lost, even when the drone flies out of sight through hallways and underground, so the pilot is always in control. HD cameras mounted on the drone transmit a live video feed, also via radio link, to goggles worn by the pilot, enabling them to get a drone's-eye view of the course as if they were in the cockpit.

The drones themselves are made from lightweight carbon fibre, so they only weigh around 800 grams, and can reach top speeds of 130 kilometres per hour. 100 colour LEDs make each quadcopter easily identifiable and are bright enough for the audience to see the action from hundreds of metres away. After every lap, each pilot's drone is replaced with a new fully-charged model, ensuring they can go the distance.

The Gates of Hell

This abandoned power plant is the ultimate drone obstacle course



1 Ready, set, go

From the start line, the drones fly along a 68-metre hallway before making a hard left turn to avoid crashing into a wall.

2 The Cathedral

After flying through the second storey, the drones make a vertical hairpin, diving onto the ground level of the Cathedral.

3 The Alley

The competitors weave in and out of iron beams, then take a sharp turn out of a window and down the outside alley.

4 Turn around

Once they have passed the back of the building, the drones fly around a pole and then back in through another window.

5 The Coal Room

At the end of the hallway, the drones complete a sharp vertical drop into the basement and pull a 180-degree turn.

6 The finish line

After two laps of the course, each 1km long, the drones cross the finish line at the end of the basement hallway.

How does antivirus software work?

How is your computer protected from malicious threats?

Above
Antivirus software has to deal with constantly evolving threats from new and changing viruses

Antivirus software basically does two jobs. First it identifies a virus threat, then it does something about it. The major technique for identifying viruses is to compare what's happening on your computer with a 'dictionary' of viruses, and react if a match is detected. As there are always new viruses, the dictionary needs to be regularly updated. However, antivirus software also looks out for programs behaving suspiciously, so it can alert you to things that might be viruses but aren't in its dictionary. Antivirus software runs constantly, checking activities as they happen, but can also scan your files. Depending on how a virus is detected, the software might warn you not to use an infected program or webpage before it strikes, or if your files are infected, it will quarantine them or delete the virus.

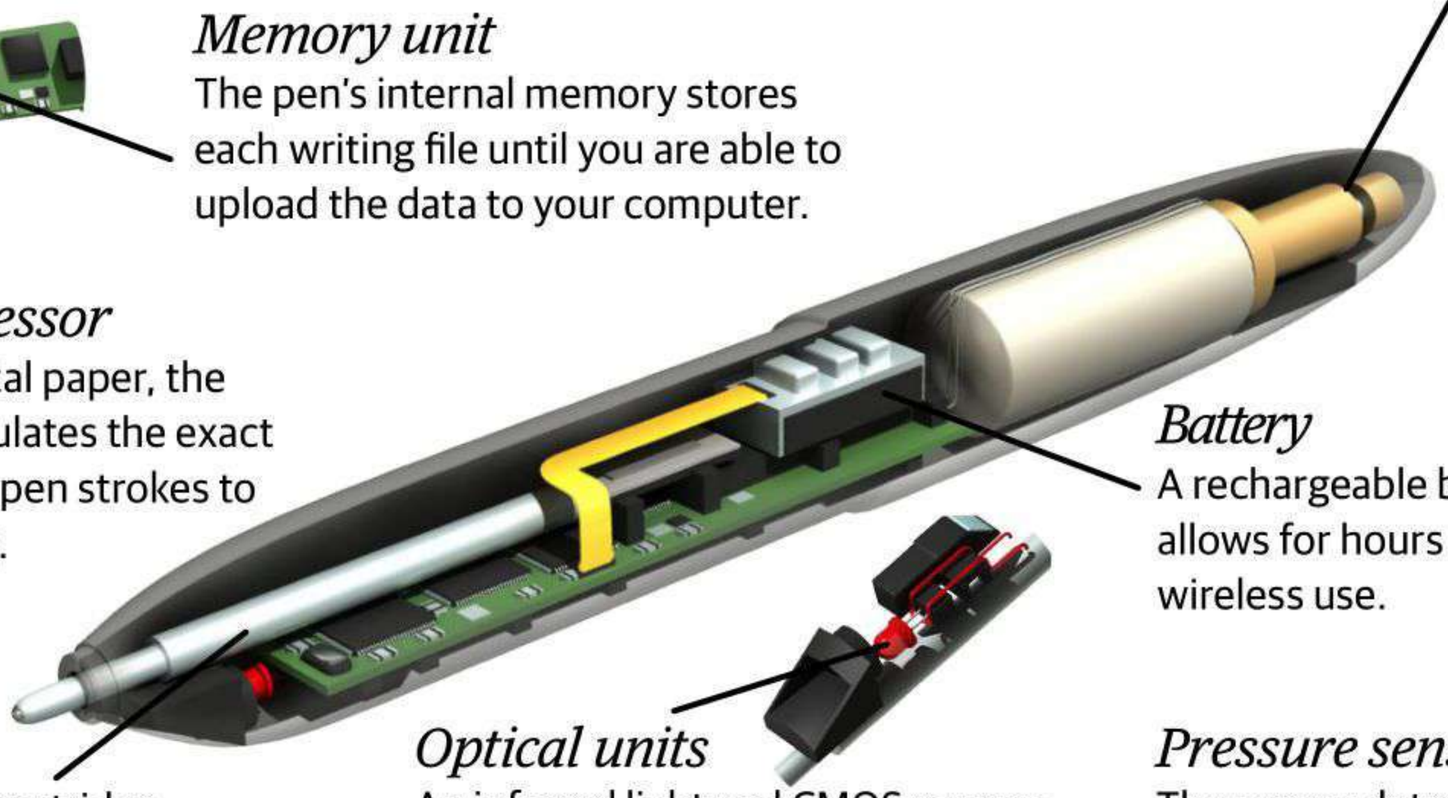
How can you take notes with your computer?

Say hello to the future of note taking, with pens that are able to talk to your computer

Revolutionising the way we take notes forever, digital pens use the same kind of technology that optical computer mice have used for decades to understand what we write on paper and translate it to a digital platform. An LED and light receiver track the way the pen moves (helped with compatible digital paper in some models), which can then be uploaded to a computer where a digital version of your handwritten notes will be waiting for you. Some models can simply turn your handwriting into a digital file, while others can translate your notes into handy text documents.

Inside a smartpen

The handwriting hardware that helps you say goodbye to typing up your scribbles



Memory unit
The pen's internal memory stores each writing file until you are able to upload the data to your computer.

Image processor
Used with digital paper, the processor calculates the exact coordinates of pen strokes to digitise writing.

Ink
A refillable ink cartridge helps the user to write more naturally for optimal use.

Optical units
An infrared light and CMOS camera capture the pen's movement over the paper dots.

Bluetooth antenna
Some models can transfer through wired connections, while others use wireless methods such as Bluetooth connectivity.

Battery
A rechargeable battery allows for hours of wireless use.

Pressure sensor
The sensor detects the pressure of your writing for an accurate representation of your handwriting.

Are electronics designed to break?

Are our devices programmed to fail after a certain amount of time?

Above
The policy of designing products to break easily is called planned obsolescence

Many devices are only designed to have a short life. In some cases it's because designing them to last longer would make them expensive, yet often it's deliberate. Manufacturers use materials they know will wear out or break easily, make maintenance difficult, or design circuits to get gradually degraded by too much heat. Ideally, this leads to products failing just after the warranty runs out.

What are the metals in your phone?

Discover the hidden treasure inside your handheld device

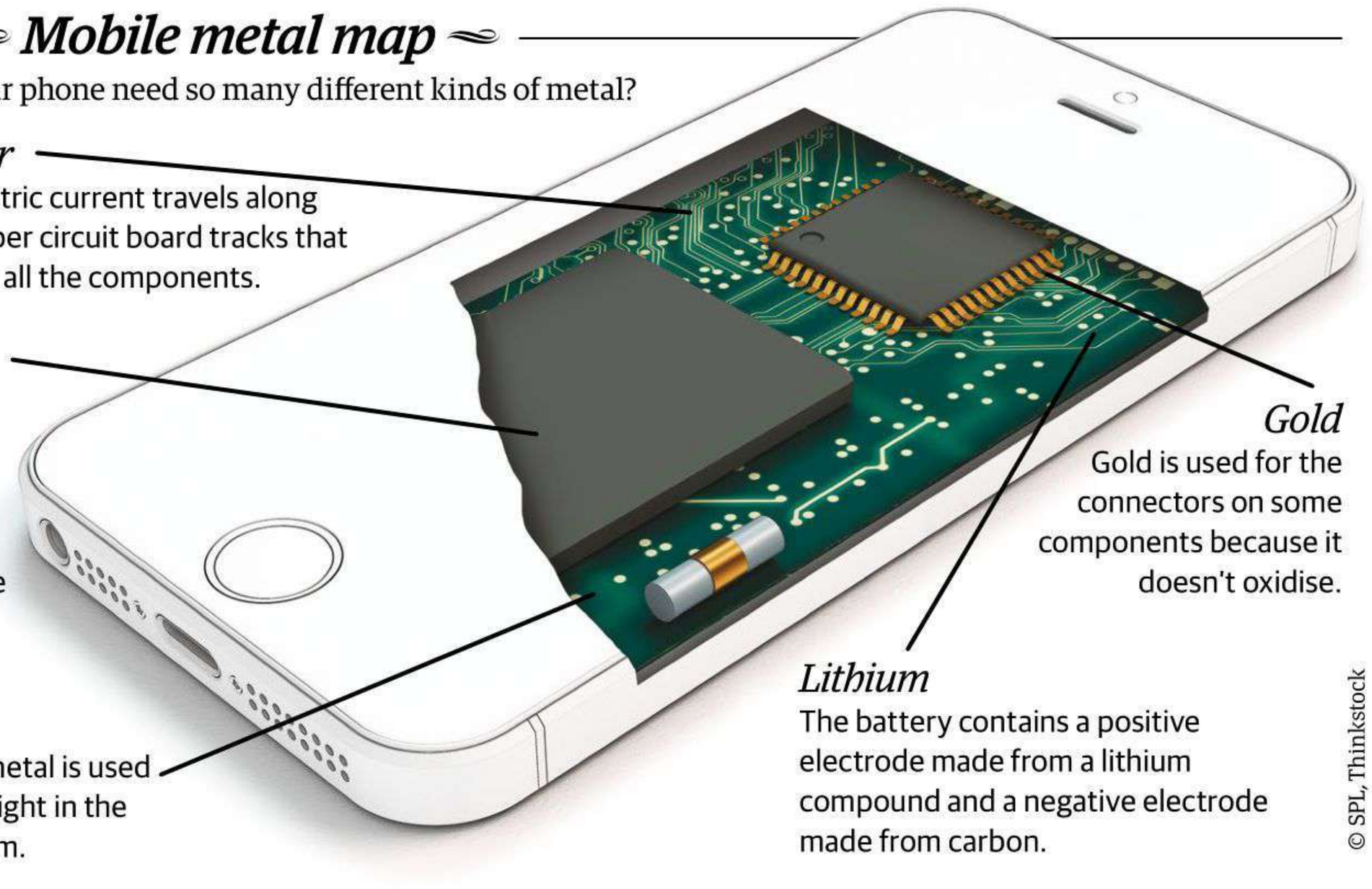
The average smartphone contains up to 62 different metals, some of which are rare and valuable. As much as 15 per cent of the phone's weight is accounted for by copper, which is used to make the tracks that conduct electricity between components. Copper is used because it has low resistance and is fairly soft.

Gold is nearly 600 times more expensive than copper but has slightly higher resistance. It is still favoured for certain connections on a phone circuit board because it doesn't corrode. It's harder to solder, because it dissolves into the normal tin-silver-copper solder alloy used in the electronics industry. Gold contacts need to be attached using special indium-tin solders or bonded directly using both heat and ultrasound energy.

A typical smartphone only contains about 40 milligrams of the metal tantalum but it is crucial to the miniaturisation of mobile phone technology. Used to make powerful capacitors, which store electricity and are a fraction of the size of ordinary electrolytic capacitors.

Mobile metal map

Why does your phone need so many different kinds of metal?



Copper
The electric current travels along the copper circuit board tracks that connect all the components.

Tantalum
Electric charge is stored in tiny, surface-mounted capacitors made from tantalum; these regulate the electric current.

Tungsten
This very dense metal is used as the counterweight in the vibrate mechanism.

Gold
Gold is used for the connectors on some components because it doesn't oxidise.

Lithium
The battery contains a positive electrode made from a lithium compound and a negative electrode made from carbon.

What is data roaming?

Explore the system that can rack up massive phone bills

If you want to go online on your smartphone abroad, other countries aren't covered by your mobile network. They will have agreements with foreign mobile companies to allow their customers to connect to other networks as a guest. When you arrive in another country, a local network identifies your phone as belonging to a partner network, and connects you to the internet through their systems.

Right
Data roaming enables you to connect your smartphone to the internet when you are in other countries

Why do computers use binary code?

How does the electronic language work?

Below
The ones and zeros of binary code are the native language of computer chips

Binary code is a way of representing data or instructions using just ones and zeros, and is the native language of computers. This is because the chips that computers are made of contain billions of tiny electronic switches known as transistors. Like other switches, these transistors have two settings, either on or off, or to put it another way, one or zero. So deep down, the electronics inside computers can only understand binary code. Everything that you do on a computer has to be converted into binary in order for the computer to process it. This string of ones and zeroes is then converted back into the output that you can see on the screen, with the computer handling the 'translation'.

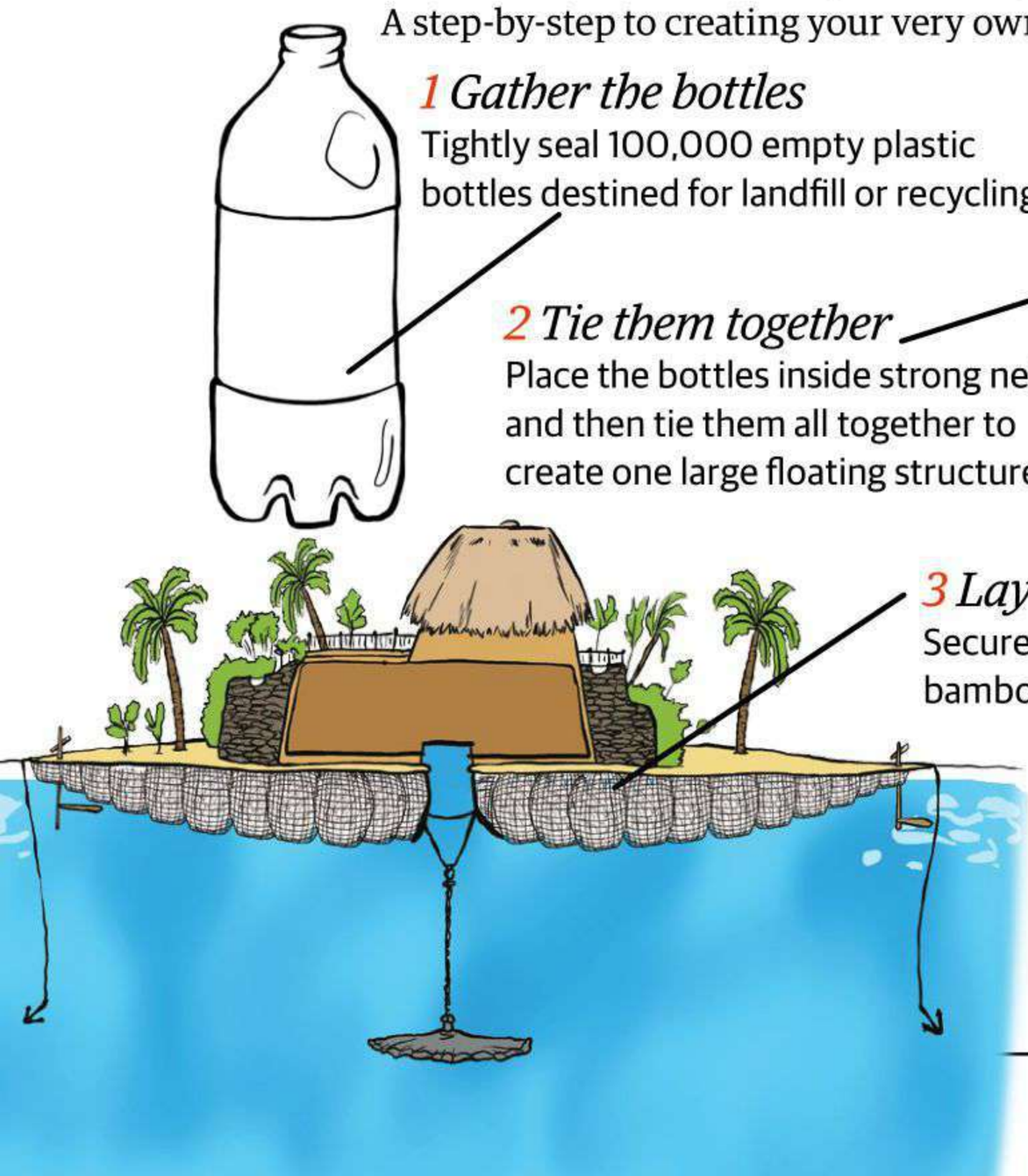
What are rubbish islands?

Building houses on floating plastic bottles is the ultimate in eco-living

Joyxee Island floats just off the coast of Mexico on top of approximately 100,000 plastic bottles. As the bottles are sealed and kept in darkness beneath the island, they don't deteriorate in the Sun's ultraviolet rays, and the roots of mangroves planted above help to hold them all in place. The island is 25 metres in diameter and strong enough to support a two-storey home, complete with a solar-powered waterfall and a wave-powered washing machine. The island is anchored in place by wooden posts driven into the seabed, and is also tethered to the coast by a long rope.

How to make a floating island

A step-by-step to creating your very own eco-paradise



1 Gather the bottles

Tightly seal 100,000 empty plastic bottles destined for landfill or recycling.

2 Tie them together

Place the bottles inside strong nets and then tie them all together to create one large floating structure.

3 Lay down some roots

Secure pallets of plywood and bamboo on top and cover them with sand and soil. Plant mangroves so that the roots will help hold the whole structure together.

Land reclamation success stories

New York

Manhattan Island used to be a thin crop of marshland, but since 1609 it has expanded. The southwest tip was once part of the Hudson River.

Sydney Olympic Park

The area on which the 2000 Summer Olympics were held was originally wetland, and it cost over $100 million to decontaminate it.

Netherlands

Vast areas of the Netherlands have been reclaimed from lakes and the North Sea. Today, about 27 per cent of the Netherlands is below sea level.

Do we know the science behind a BBQ?

It takes serious knowledge to grill a perfect burger

Whether your barbecue is plumbed into a gas tank, or is a more traditional coal or wood-fired burner, there are two key ingredients for a good grilling: heat and smoke.

Barbecuing is very different from cooking on a hob or in an oven. On the hob, the heat moves from ring to pan to meat mainly by conduction. The metal pan is in physical contact with the heat source, and the meat is in direct contact with the pan. Alternatively, when meat is cooked in an oven, heat mainly travels by convection. The element heats the air, which circulates around the oven, and around your food.

On a barbecue, however, the burgers and sausages are far above the coals, and with the lid off, convection isn't nearly as important as it is in the oven. Instead, most of the heat comes from infrared radiation. Radiant heat is absorbed by dark surfaces, so lining your barbecue with shiny foil can help to direct all of the warmth to where you need it. When using coals, waiting long enough for them to turn white with ash ensures that they are evenly heated through.

As the meat dries out on the outer edges, it starts to brown; sugar reacts with protein to create that distinctive barbecued crust. You can do this indoors on the hob too, but to get that authentic barbecue taste, you need smoke.

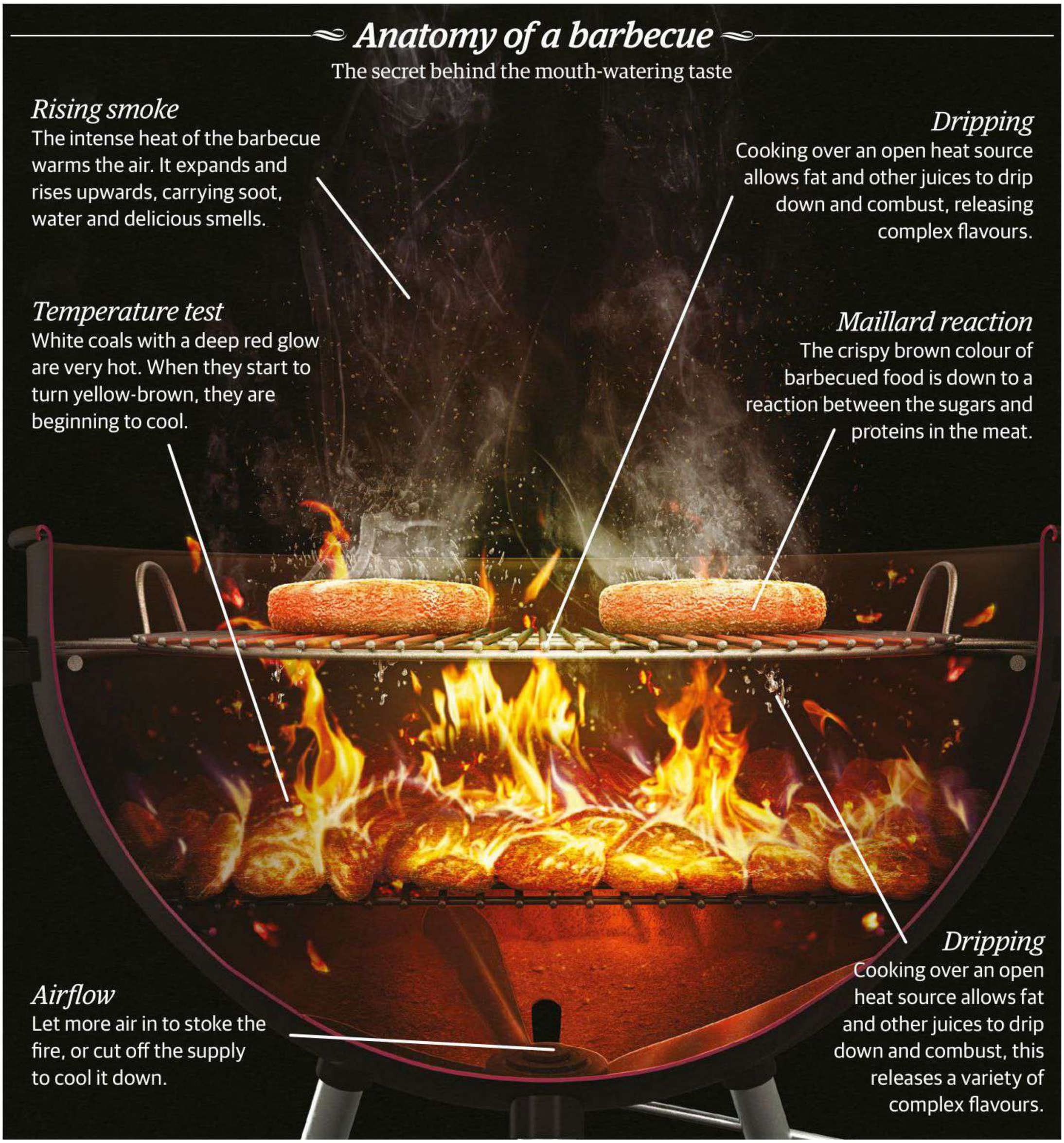
When fats and juices drip down on to the barbecue, they burn, releasing flavour and odour molecules that rise up, filling the air with the scent of summer, and sticking to the surface of the meat.

© Dreamstime

Below
Drips of fat create little flames, releasing flavour molecules into the air

Anatomy of a barbecue

The secret behind the mouth-watering taste



Barbecue tips

1 Wait for the coals to go white

Not only does this mean they are hot enough, the coating of ash will help to control the amount of heat they radiate.

2 Preheat the grill

If you're after those charred grill lines, you need to make sure that your grill is scorching before you put your burgers on.

3 Don't bother searing

This technique is quite often thought to seal in the meat's juices, but it may actually do the opposite.

4 Turn frequently

No one likes a burnt sausage. Make sure you keep them moving to prevent one side heating up too much.

5 Let it rest

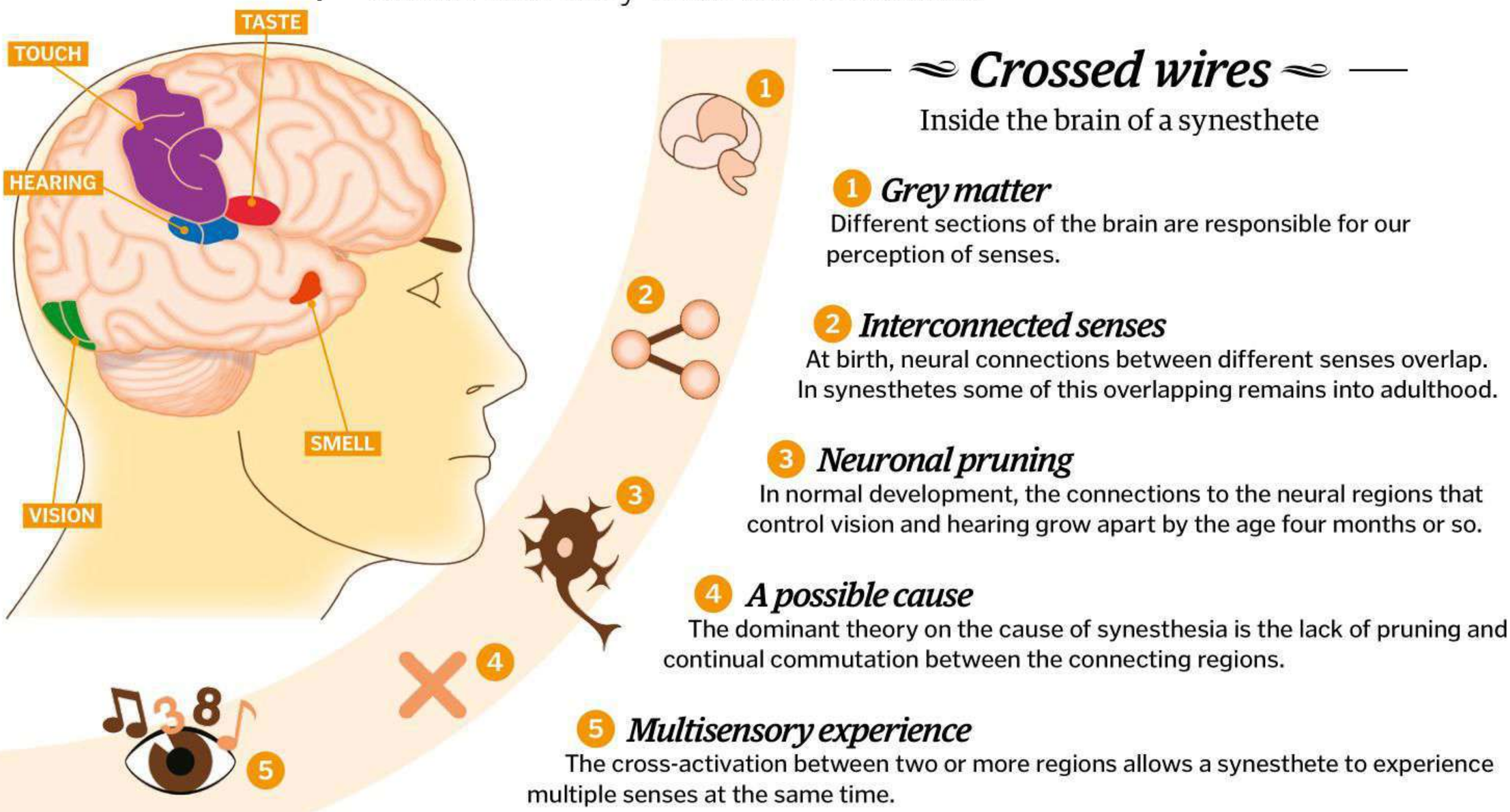
By doing this, you are allowing the muscle fibres to relax a little, so they hold on to more water when the meat is cut.

What is synesthesia?

Why can some people see the colour of music or taste the flavour of words?

Synesthesia is a condition that affects around four per cent of the global population, and enables them to experience the world in a different way. During our infant development, the connections in our brains are held close together; areas in the brain that control taste, hearing, sight, smell and touch are overlapped. As we grow into adults those connections are pruned apart, but it is thought that this process is interrupted somewhat for those with synesthesia. This blending of sensory information can mean that people see the colour of sound. Those with number-form synesthesia see numbers in physical space in varying forms and shapes. Many synesthetes often aren't even aware that they have the condition.

Below
As we develop, our brain connections can overlap and cause Synesthesia



Crossed wires

Inside the brain of a synesthete

1 *Grey matter*
Different sections of the brain are responsible for our perception of senses.

2 *Interconnected senses*
At birth, neural connections between different senses overlap. In synesthetes some of this overlapping remains into adulthood.

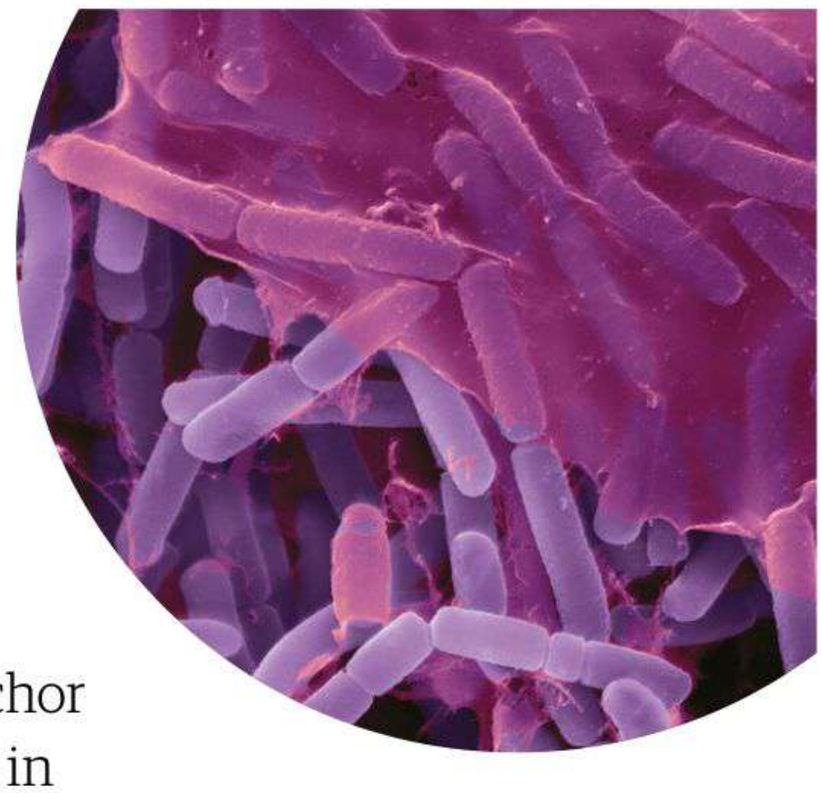
3 *Neuronal pruning*
In normal development, the connections to the neural regions that control vision and hearing grow apart by the age four months or so.

4 *A possible cause*
The dominant theory on the cause of synesthesia is the lack of pruning and continual commutation between the connecting regions.

5 *Multisensory experience*
The cross-activation between two or more regions allows a synesthete to experience multiple senses at the same time.

What is a biofilm?

How microorganisms start working together as a giant, gooey mat



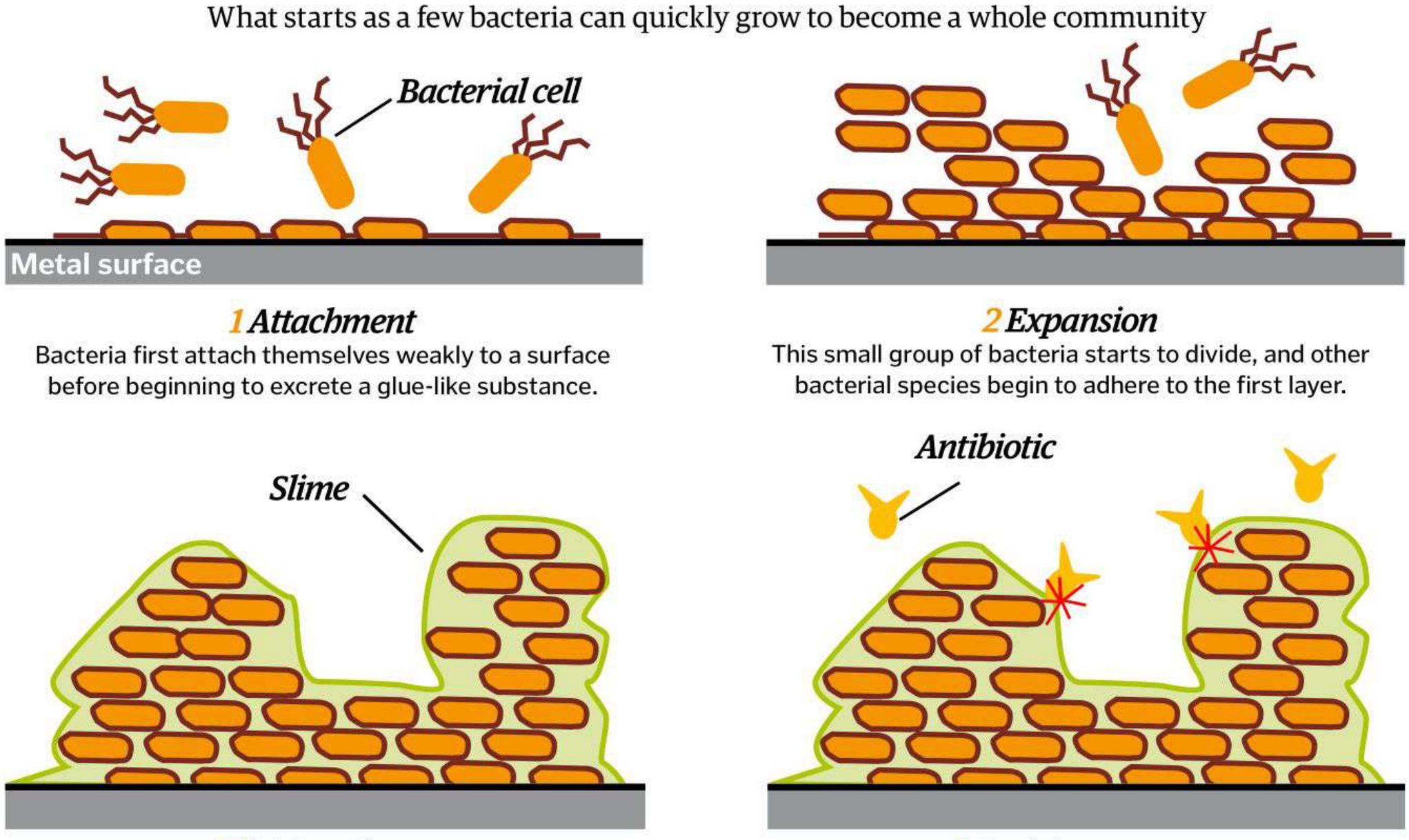
Above *Most ear infections are caused by biofilms*

Biofilms are layers of microorganisms held together by a sugary glue. The individuals at the bottom anchor themselves tightly to a surface, and the ones living in the layers above remain connected by a gel that shares genetic information and chemical signals. Together, they are stronger and more resilient than they would be alone.

These living structures can grow on medical implants, inside water pipes, and even on your teeth as plaque. They cling so tightly that they can't just be washed away, and their protective film provides some shielding against antibiotics and the immune system, making them even harder to get rid of.

Building a biofilm

What starts as a few bacteria can quickly grow to become a whole community



1 Attachment

Bacteria first attach themselves weakly to a surface before beginning to excrete a glue-like substance.

2 Expansion

This small group of bacteria starts to divide, and other bacterial species begin to adhere to the first layer.

3 Maturation

The bacteria start working together as a community. They produce a sticky film, sharing nutrients and communicating.

4 Resistance

The community can withstand assault from the outside, fending off toxic chemicals, drugs, and even the immune system.

Is the five-second rule real?

Is there any logic behind it?

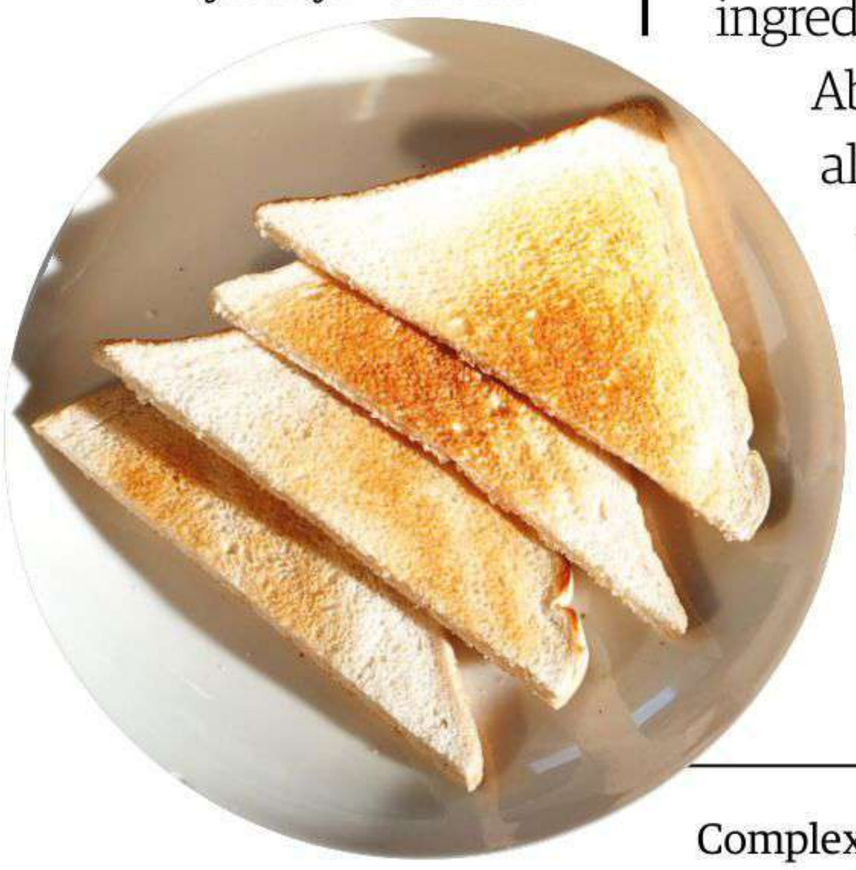
Below
Whether dropped food is safe to eat depends on the type and number of pathogens present on the floor

Every schoolchild has heard that if you pick food up within five seconds of dropping it, it's safe to eat, but is this an urban myth? To test the idea, researchers at the Aston University in the UK dropped toast, pasta, biscuits and sweets onto a variety of different floor surfaces, and tested them for the presence of common bacteria at time points between three and 30 seconds. Bacteria do transfer before the magic five seconds is up, but generally the food is still edible. Dropping food onto carpet was better than flinging it at a hard, flat surface like laminate, and dry food fared better than wet.

Why does toast burn?

What is it that makes toast smell and taste so good?

Below
Toast can go from white to charred in just a few seconds



Bread in its simplest form is made from wheat flour, yeast and water. The flour contains carbohydrates and proteins, and these are the key ingredients of a chemical reaction known as the Maillard reaction.

Above around 140 degrees Celsius, the chemical groups called aldehydes in bread start to react with the amino groups found in the wheat proteins.

The rate at which your bread turns to toast, and then to charcoal, depends on its composition, and various sugars and amino acids produce different flavour and odour molecules when they undergo the Maillard reaction. In general, the drier the slice, the faster these reactions occur, and the quicker the toast will burn.

The taste of toast

Complex chemicals are responsible for the distinctive smell and taste of toast

1 Bread
Bread contains proteins (made of amino acids) and carbohydrates (sugars).

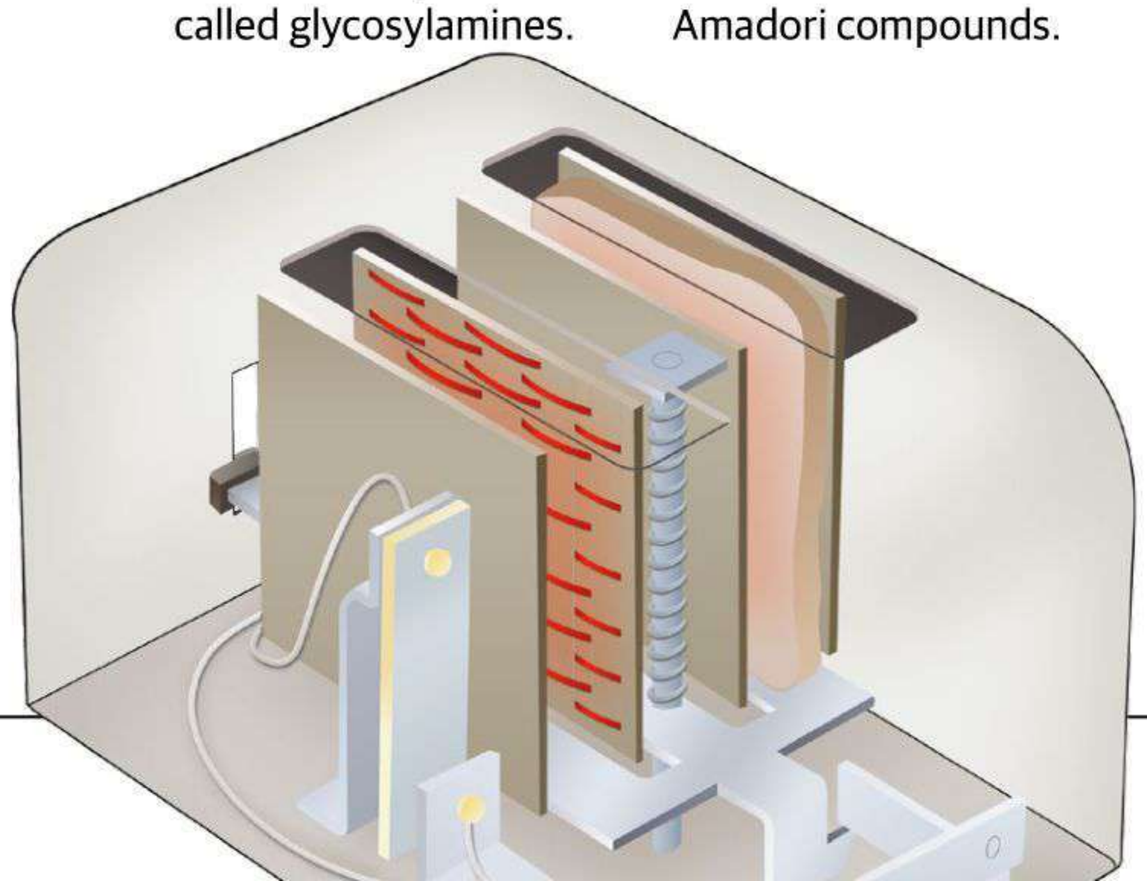
2 Heat
At temperatures above 140˚C, amino acids and sugars start to combine.

3 Sugar
The sugars found in bread include glucose, fructose, maltose and also lactose.

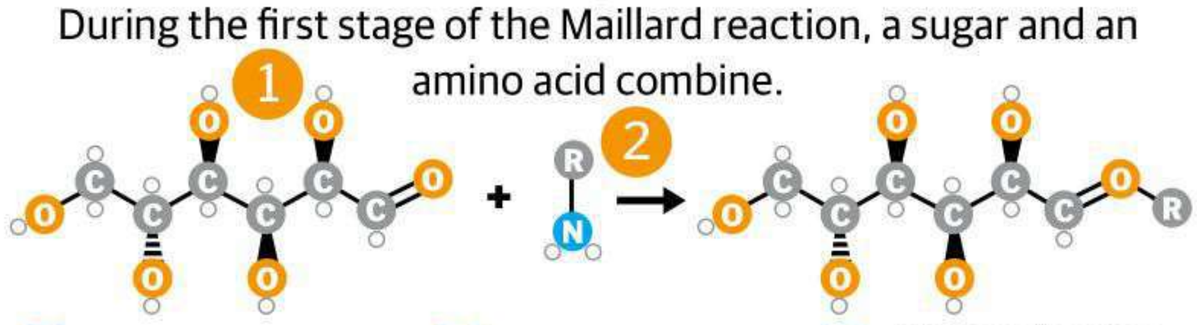
4 Amino acids
There are 20 amino acids, each with a slightly different structure.

5 Glycosylamine
Sugars and amino acids combine to form unstable compounds called glycosylamines.

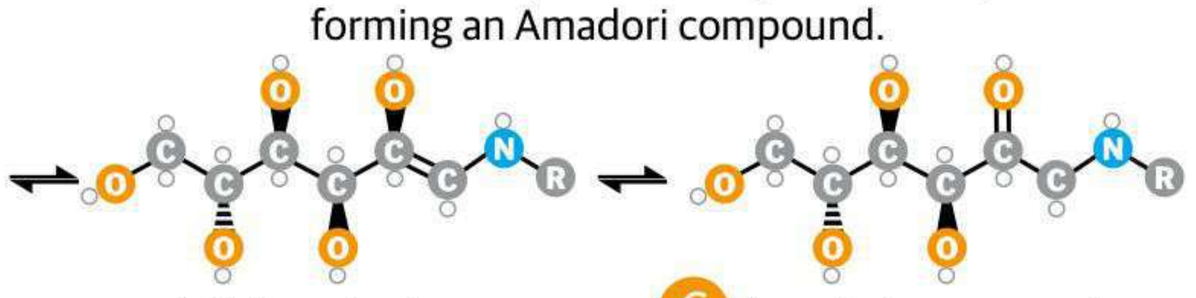
6 Ketosamine
Glycosylamines are rearranged to form ketosamines, or Amadori compounds.



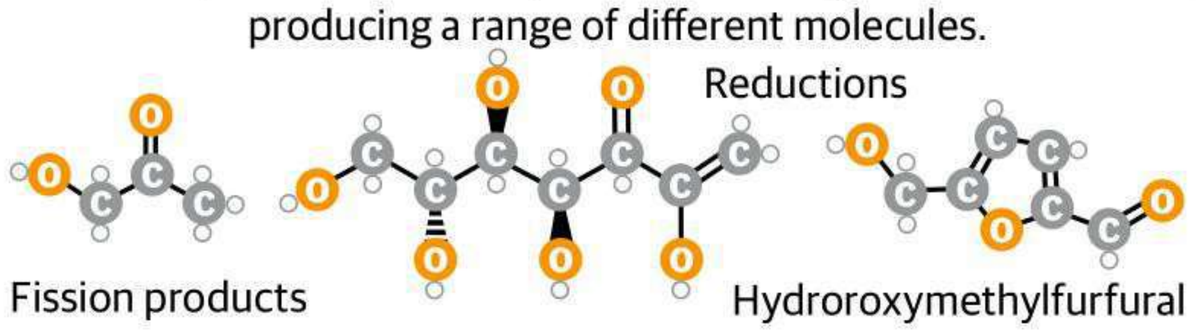
Step 1
During the first stage of the Maillard reaction, a sugar and an amino acid combine.



Step 2
The structure made in step one undergoes rearrangement, forming an Amadori compound.



Step 3
The compound made in step two can undergo further reactions, producing a range of different molecules.



What is Junk DNA?

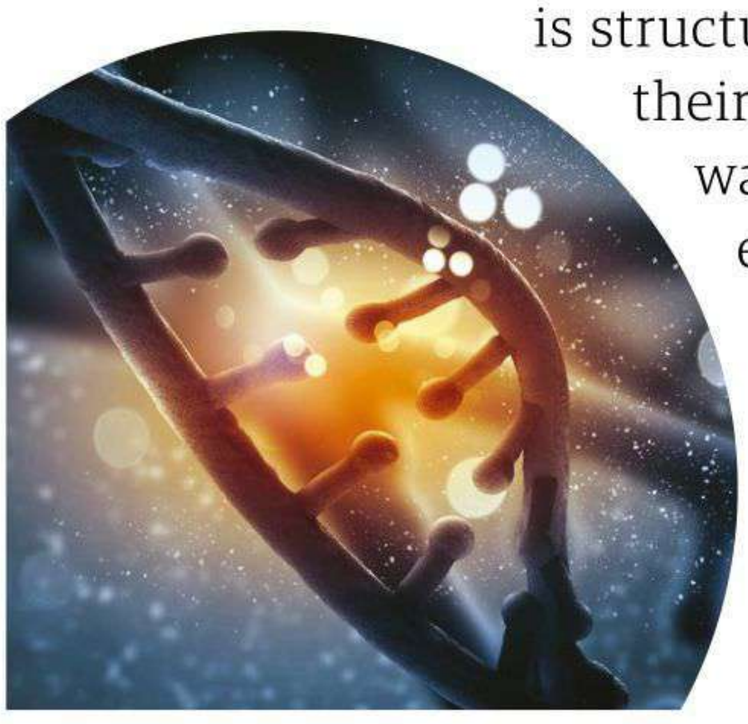
Why is there so much rubbish in the human genome?

Less than two per cent of the three billion 'letters' of the human genome contains proper genes. That leaves an overwhelming majority of our DNA code that has no obvious function – so why does it exist?

Most of the human genome is dull and repetitive, packed full of millions of copies of elements called transposons and other repeated sequences.

It might be expected that evolution would kick this stuff out, through the process of natural selection. If a stretch of DNA is useful, it sticks around and becomes a permanent part of the genome. But if not... well, it actually sticks around anyway, because evolution is a slow and imperfect process. More recent research actually suggests that this 'junk' DNA may not be completely useless.

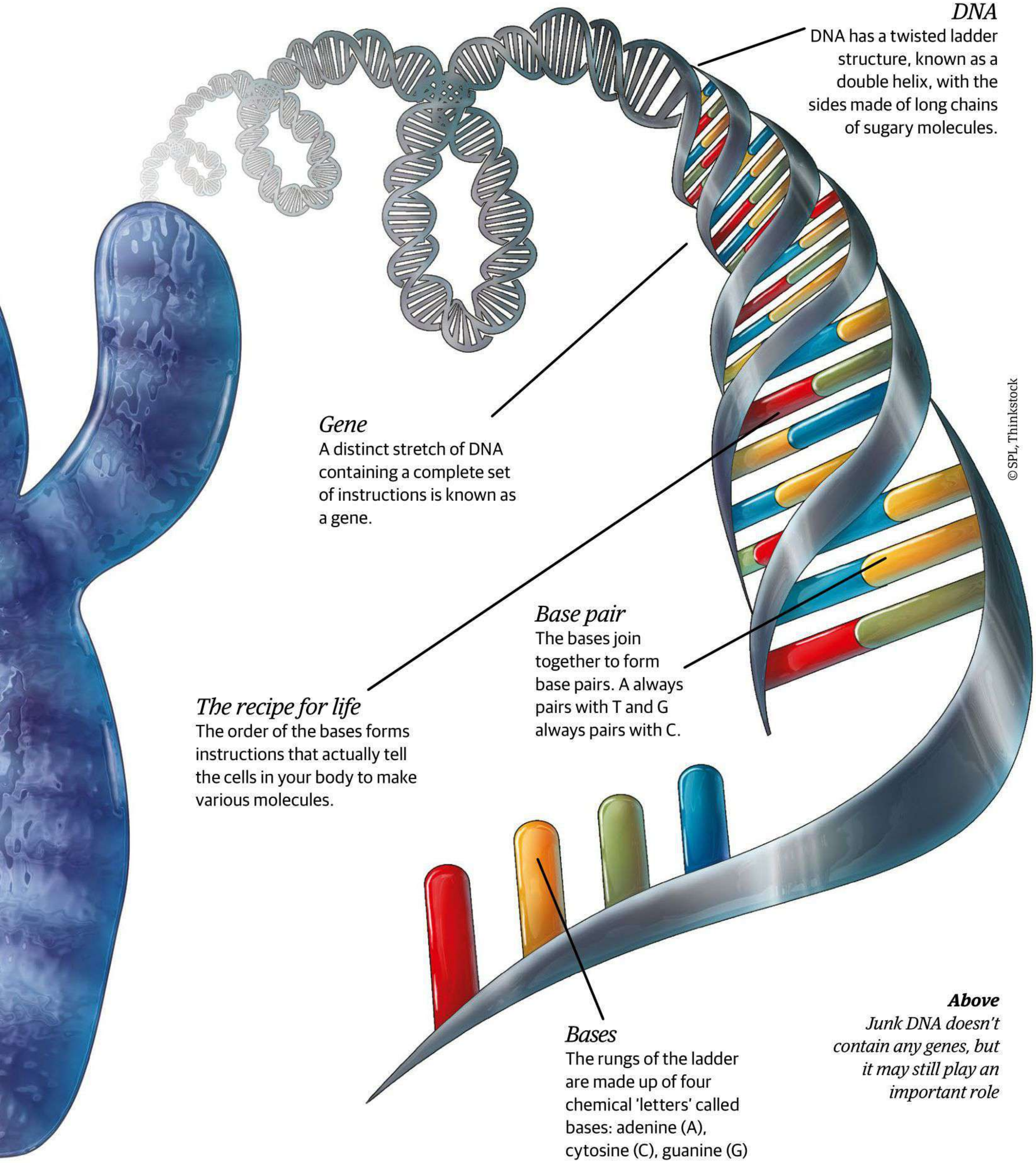
Some researchers actually think that our abundance of non-coding DNA is the biological equivalent of bubble wrap, acting as kind of protective packing around our genes and helping to dilute the impact of cancer-causing agents such as X-rays and other carcinogens. It may even be that some of the junk is structural, helping to space genes and their control switches out in the right way, although this theory has been extremely hard to prove. Using genetic engineering techniques, researchers can 'glue' a gene right next to the switch that activates it and it still works, suggesting that the precise spacing of genes isn't all that important.



What is DNA?

The complex molecule that carries your genetic information

Chromosome
Chromosomes in the nucleus of most cells consist of long strands of deoxyribonucleic acid, or DNA.



DNA
DNA has a twisted ladder structure, known as a double helix, with the sides made of long chains of sugary molecules.

Gene
A distinct stretch of DNA containing a complete set of instructions is known as a gene.

Base pair
The bases join together to form base pairs. A always pairs with T and G always pairs with C.

The recipe for life
The order of the bases forms instructions that actually tell the cells in your body to make various molecules.

Bases
The rungs of the ladder are made up of four chemical 'letters' called bases: adenine (A), cytosine (C), guanine (G) and thymine (T).

Above
Junk DNA doesn't contain any genes, but it may still play an important role

What is the science behind radioactive dating?

Learn how scientists measure time using Earth's rocks

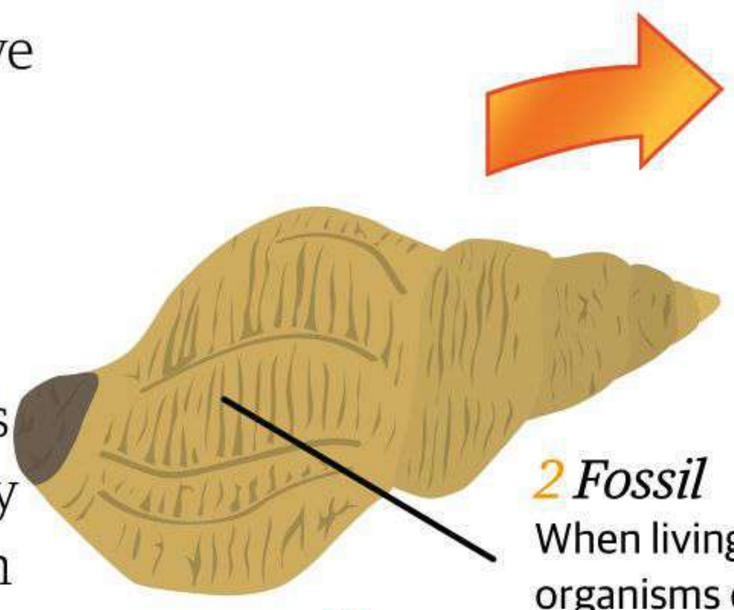
Most chemical elements remain stable over time, but there are radioactive variants of common atoms, and these are unstable. As the years pass, they gradually decay. One of the most well-known is carbon-14, which has two extra neutrons in its nucleus. Atoms of carbon-14 cannot hold on to the extra neutrons forever, and over time they will lose them to form stable, non-radioactive nitrogen-14. This decay happens at a fixed rate, like the ticking of a clock, and is known as a half-life: the time it takes for half the unstable atoms in a given mass to decay.

The carbon-14 clock allows scientists to determine the age of fossilised remains of living things. All life on Earth is carbon-based, and when animals and plants are living, they incorporate traces of naturally occurring radioactive carbon into their tissues. When they die, this process stops, and the carbon clock starts ticking. When we dig up fossils years, or even millennia later, some of this carbon will have decayed, so by measuring the amount that is left, we can tell how old the samples are.

Each of these rock clocks all tick at completely different rates. When magma solidifies to form igneous rocks, it traps radioactive potassium-40, which takes 1.25 billion years to tick down by half. Uranium-238 takes 4.5 billion years, thorium-232 takes 14 billion years and rubidium-87 takes 48.8 billion years.

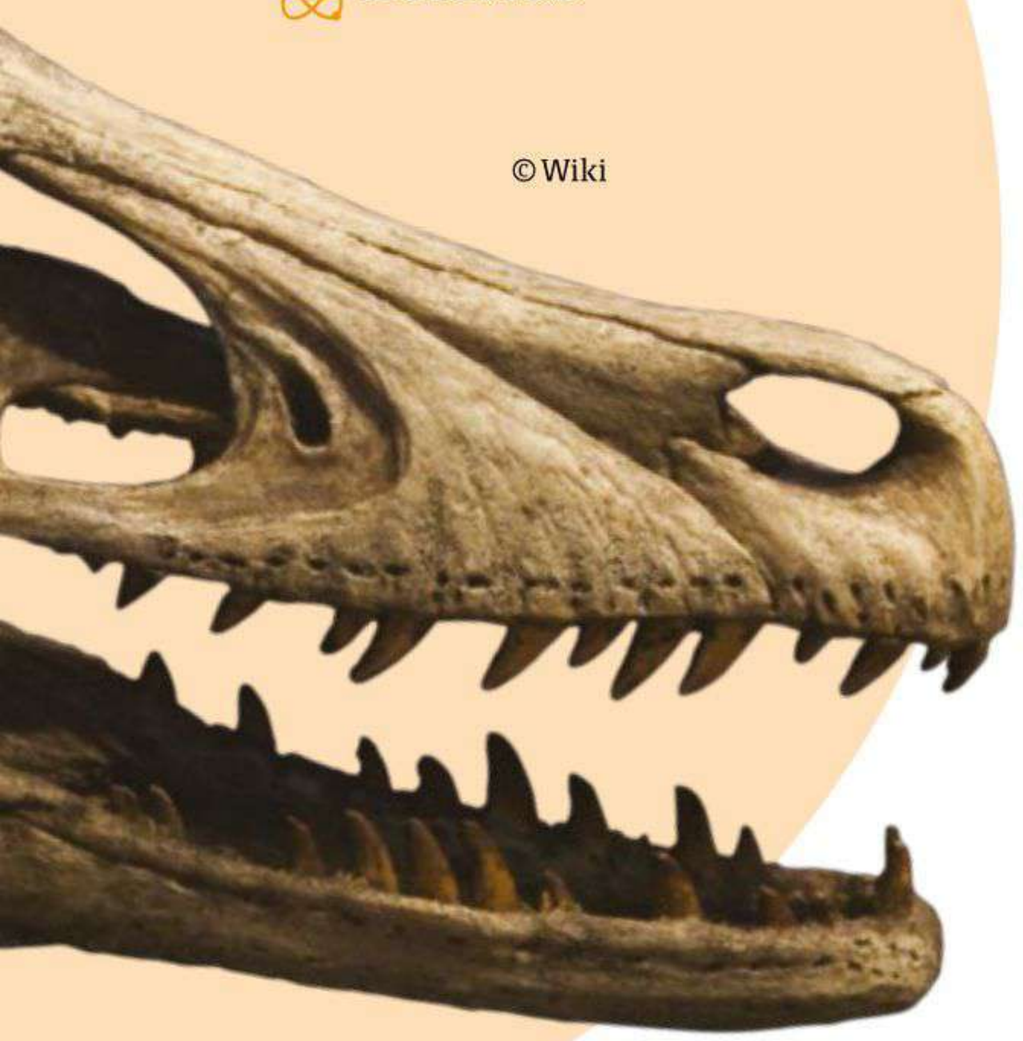
Carbon dating

This form of radioactive dating is used to pinpoint the age of once living things



2 Fossil

When living organisms die, they stop making new molecules, ensuring that no new carbon-14 is added to their remains.



© Wiki

Left
This is used to discover the age fossilised remains, like this velociraptor skull

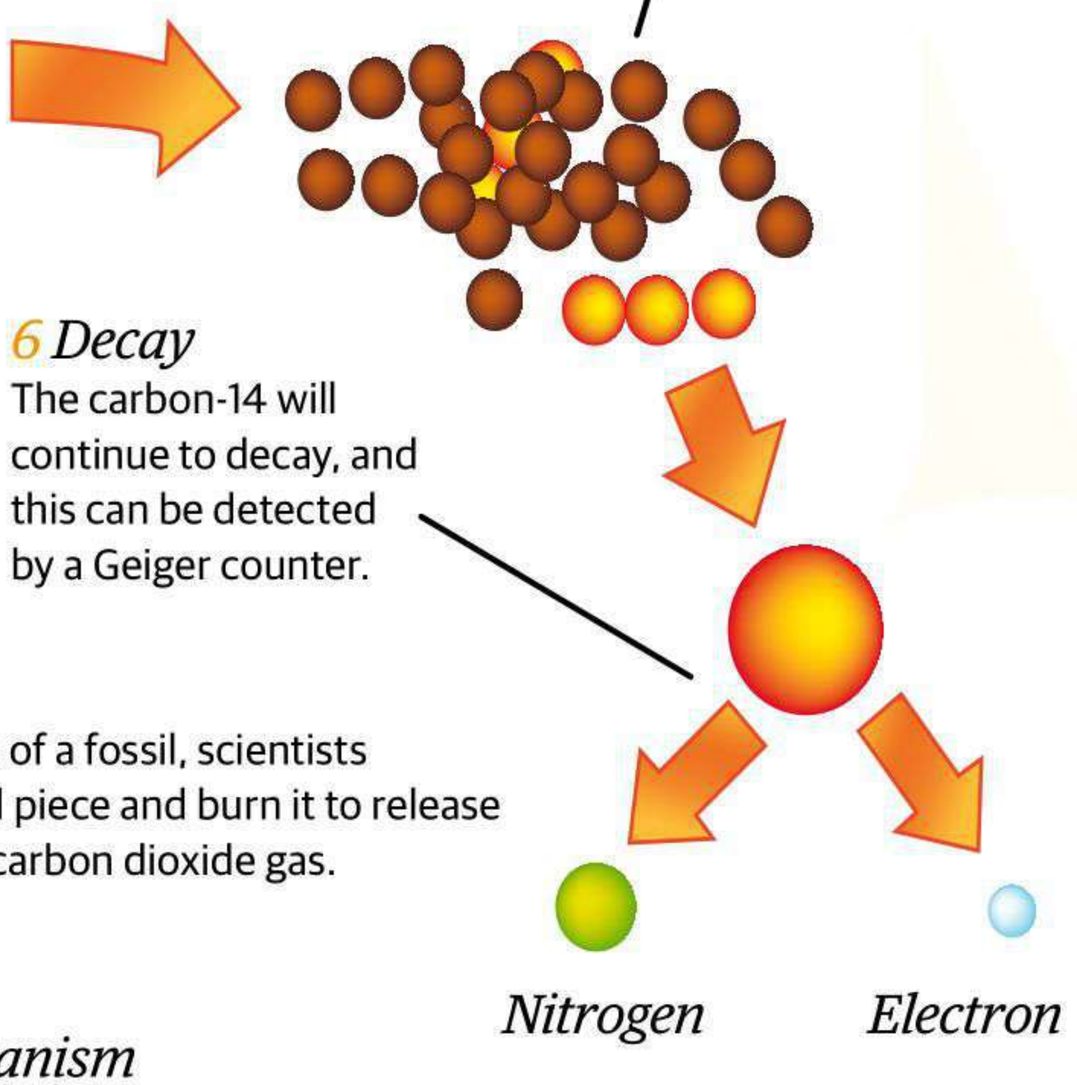
1 Living organism
Over the course of their lifetimes, living organisms incorporate small amounts of naturally occurring radioactive carbon-14 into their tissues.

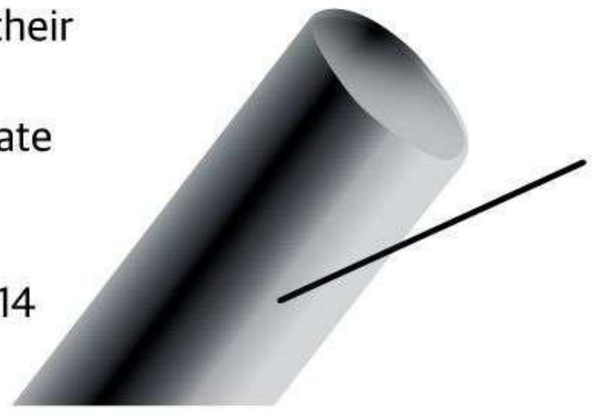
3 Ticking clock
The carbon-14 already present in the fossilised organism gradually decays.

4 Testing
To find the age of a fossil, scientists remove a small piece and burn it to release the carbon as carbon dioxide gas.

5 Carbon
The fossil contains mainly 'normal' carbon-12 (shown in brown), but also traces of radioactive carbon-14 (shown in orange).

6 Decay
The carbon-14 will continue to decay, and this can be detected by a Geiger counter.





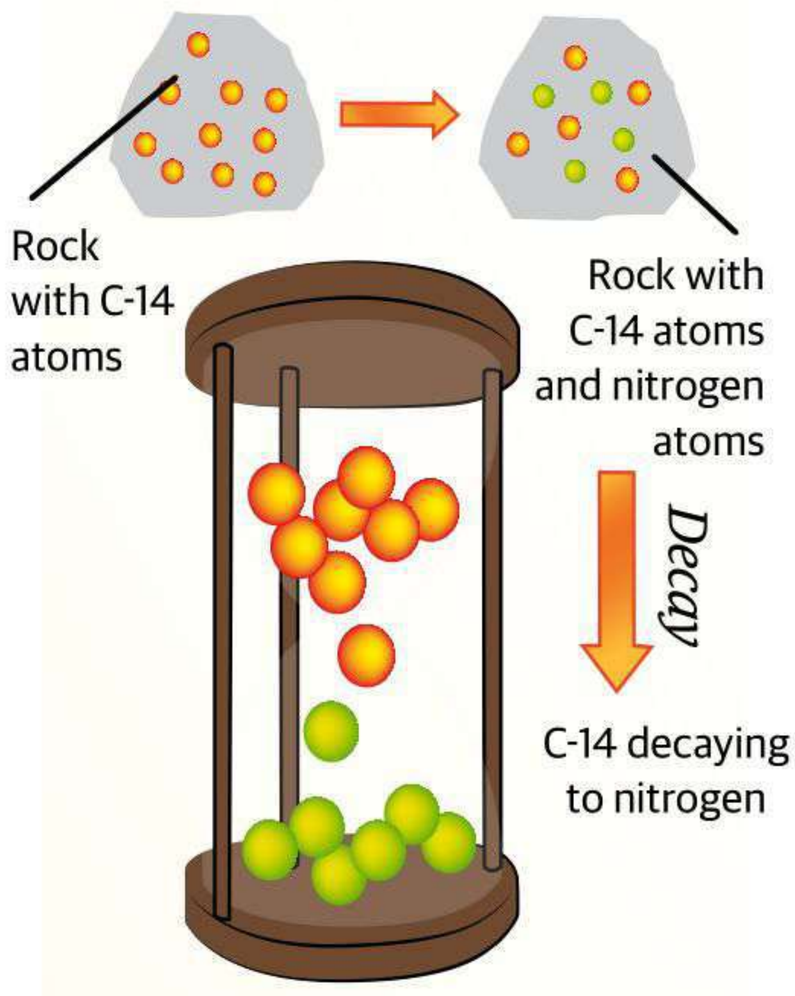
7 Proportions
The older the fossil is, the less carbon-14 will still be present in the sample.

What is a half-life?

The reason that radioactive atoms can be used as clocks is because they decay at a predictable rate. However, waiting for radioactive decay is a bit like waiting for corn kernels to pop. We know approximately how long it should take for all the corn to become popcorn, but we can't predict which kernel will pop first.

In the same way, we don't know exactly when radioactive clocks will tick, but we do know the time it takes for half of the atoms in a sample to decay. This is known as the 'half life', and for carbon-14, it is 5,730 years.

The half-life is not affected by things like temperature, pressure, or other environmental influences, meaning that, whatever was going on in the world at the time, these molecular clocks would continue ticking, keeping time and allowing scientists to look back and figure out how old things are.



Above
By measuring the chemical make-up of a rock, we can tell how long the clock has been ticking

How does baking bread work?

How chemistry and biology help to make the perfect loaf

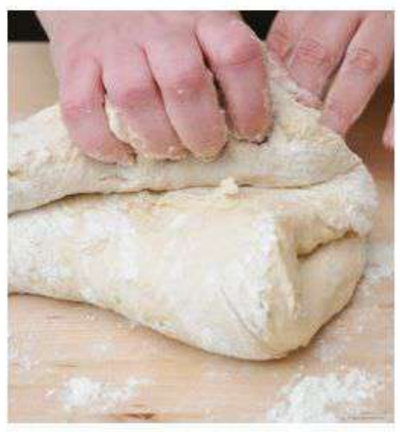
Ancient Egyptian hieroglyphs show that humans have been baking bread for thousands of years. The first attempts consisted of ground wheat and water that was left to harden in the Sun. It's possible that one mixture was left longer than usual and the naturally occurring yeasts enabled the dough to ferment. The resulting loaf would have risen, leading the Egyptians on a mission to isolate the yeast so that it could be added to every batch of bread. This key ingredient is just a part of the amazing chemical and biological processes that create a food enjoyed all over the world.

Making bread with science

A step-by-step guide to harnessing the power of yeast for a light, fluffy texture

Mix the ingredients

Put flour, yeast, salt and water into a bowl and mix together to form dough. Flour when combined with water, forms gluten. This gives dough its stretchy, and almost elastic properties.



Start kneading

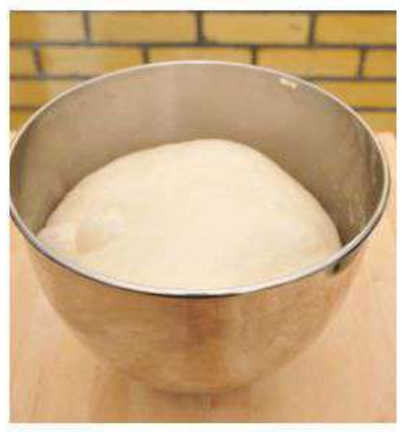
Place the dough on a flour-covered surface and press it with the palm of your hand before folding it over, turning it and repeating again and again. You can stop kneading when the dough has a smooth, elastic surface.

Let it rise

Place the dough in a clean bowl, cover with cling film and leave it in a warm place. The yeast feeds on sugars in the flour, producing carbon dioxide which gets trapped and forms bubbles, so the dough rises.

Knock back the dough

Once the dough has doubled in size, take it out of the bowl and gently knead it again. This will knock out some of the air to get rid of any large bubbles. Now leave the dough to double in size again.

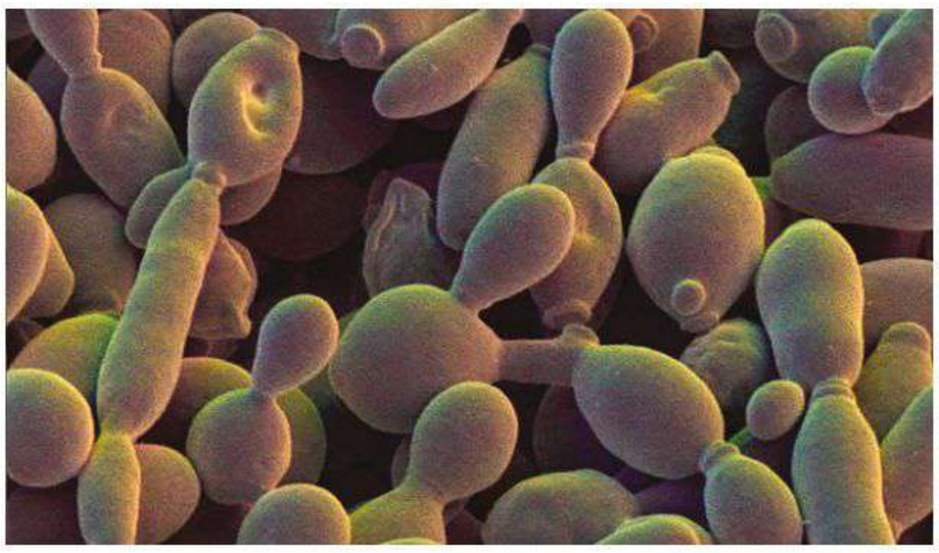


Bake in the oven

Heat causes the gases to expand and increase in size. The yeast dies and the gluten and starch solidify so the dough can't expand further. Leaving a light and fluffy centre, and the sugars caramelise to form a crust.

What is yeast?

Discover how yeast makes bread possible



© Corbis

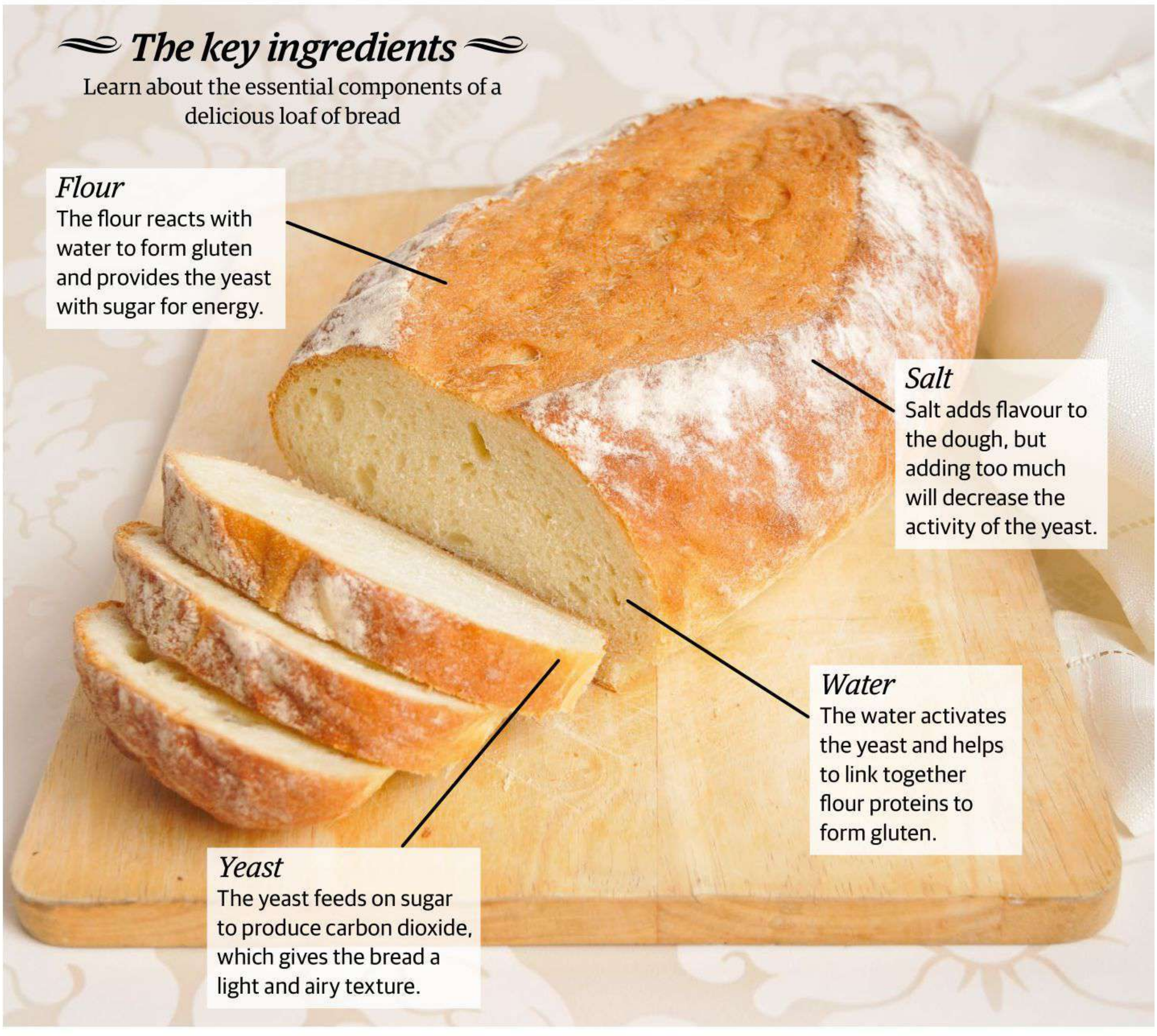
Above

Baking yeast is typically a species called Saccharomyces cerevisiae, which is also used to make beer

It's strange to think that you are adding a living organism into your bread dough, especially when you consider it is actually a fungus. Thankfully though, the packets of yeast you buy at the supermarket contain a different species from the ones that cause nasty infections. Baker's yeast usually comes in the form of capsules made from dried yeast. When these capsules come into contact with moisture, the shells dissolve to release the live yeast inside. This gets to work feeding on the sugar created by enzymes that digest the starch content of the flour. As well as carbon dioxide, this process also produces alcohol, which burns off during baking but leaves behind a slightly sour flavour. Yeast works best at warm temperatures, so it is best to leave the dough to rise in a warm place, but cover it to prevent the moisture from evaporating.

The key ingredients

Learn about the essential components of a delicious loaf of bread



© Corbis

Why do boomerangs come back?

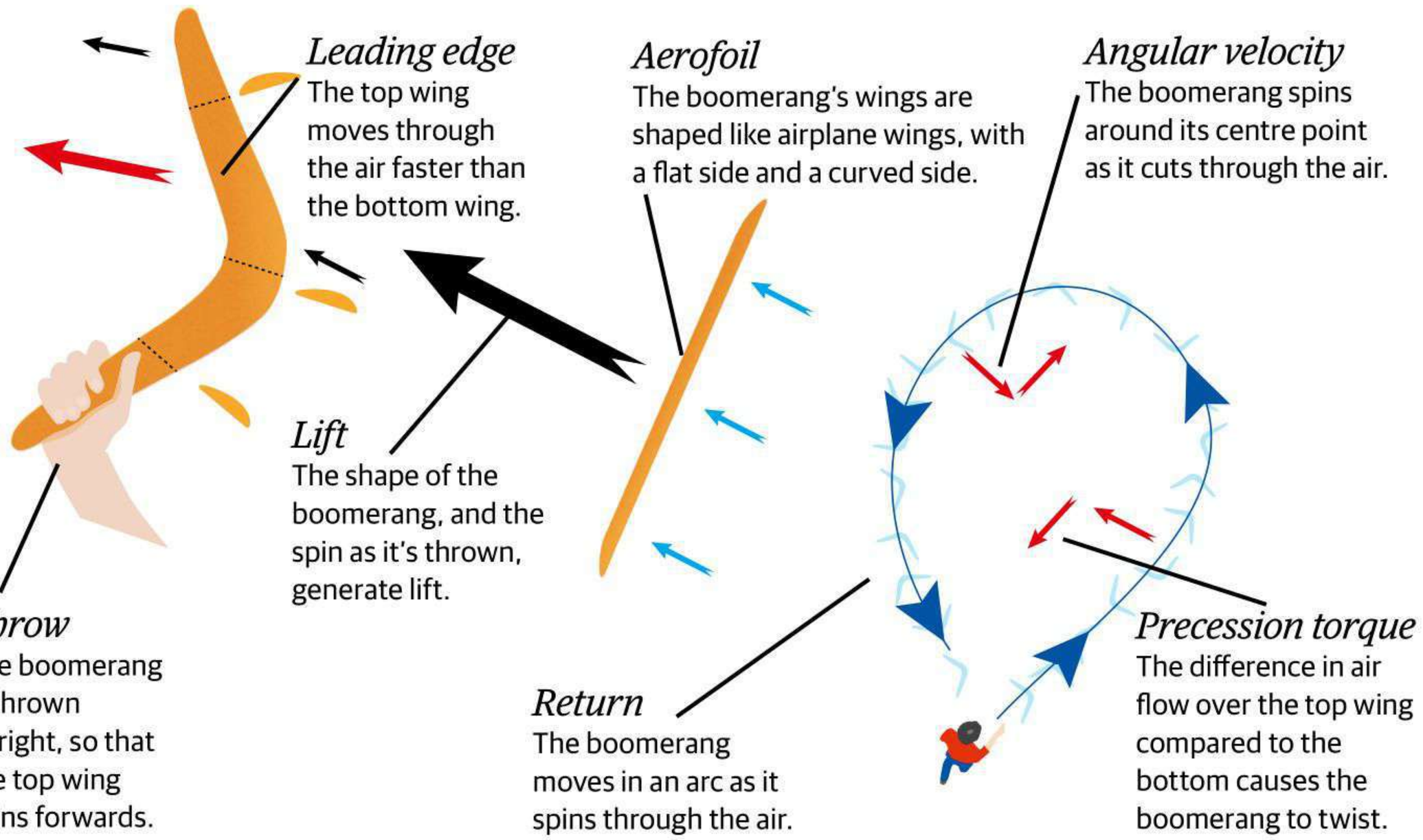
The secret to the flight path of a boomerang is in its wings

A stick will tumble through the air in a relatively straight line before crashing to the ground, but a boomerang curves in a wide arc and comes right back to your hand. Boomerangs have two wings, each with an aerofoil design: one side is flat, and the other side curved. This shape creates a difference in pressure above and below it, which generates lift. The placement of the wings is the secret to getting the boomerang to return. The sharp, leading edge of each wing face the same way, turning the curved stick into a propeller.

The combination of the spin and throw mean that the top wing moves faster than the bottom, and as this happens, the boomerang starts to tilt. The effect is called precession. The boomerang leans to the side, turning full circle before coming back to where it was thrown.

Flight path

What happens to a boomerang as it flies through the air?



Is there such a thing as a 'male' or 'female' brain?

Does our grey matter differ between men and women?

Above
A recent study has debunked the idea that there are two distinct brain genders

In 2015, a study led by Daphna Joel at Tel Aviv University in Israel looked at MRI scans of more than 1,400 different brains belonging to both men and women. Researchers looked at the various anatomical traits, such as size, weight and tissue thickness, of the different parts of each brain and found 29 brain regions that are generally different sizes in males and females. However, looking at each individual brain scan, they found that less than eight per cent had all of the brain features that typically belong to one particular gender, as the majority had a mixture of both 'male' and 'female' traits.

What is the biology of hunger?

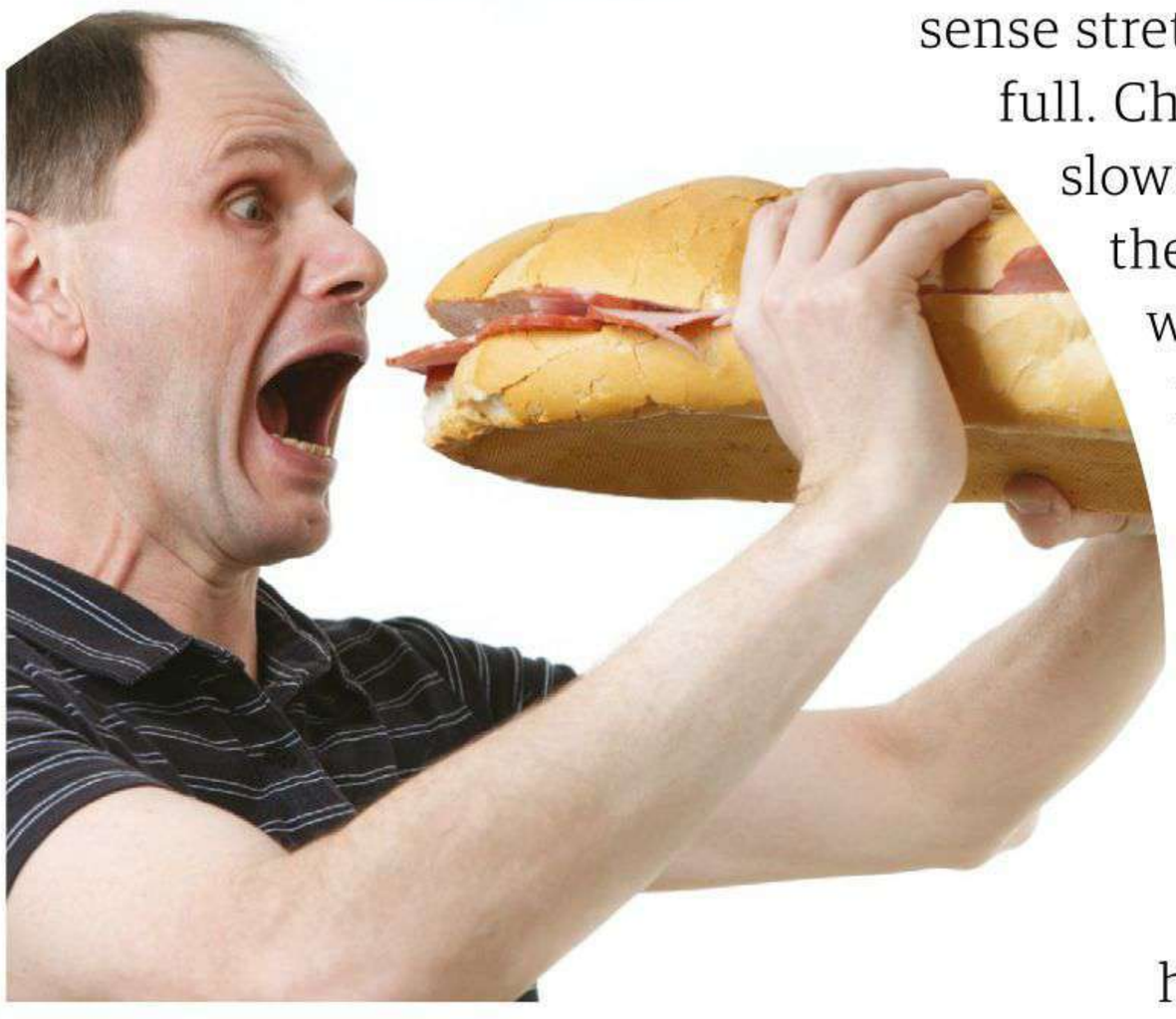
Grab a snack, and then find out what's really going on in your rumbling tummy

The feeling is too familiar: a growling in the pit of your stomach that starts around late morning when breakfast is just a memory and lunchtime is still a tiny speck on the horizon. It's hunger - a feeling that begins with the hormone known as ghrelin. Once your body has finished digesting and using up the energy from your last meal, your blood sugar and insulin levels drop. In response, ghrelin is produced in the gut and travels to the brain, letting it know that sustenance is needed. The brain then commands the release of a second hormone called neuropeptide Y, which stimulates appetite.

Once you have eaten, nerves in your stomach sense stretching, letting your brain know you're full. Cholecystokinin improves digestion by slowing down food being emptied from the stomach into the small intestine, as well as stimulating the production of molecules that help to break down food. GLP-1 tells the pancreas to release more insulin and also reduces appetite. PYY is secreted into the bloodstream by the small intestine after eating, binding to receptors in the brain to make you feel full.

Once all of the food is digested, the hunger cycle continues

Below
The stress hormone, cortisol, can increase appetite and cause a person to overeat



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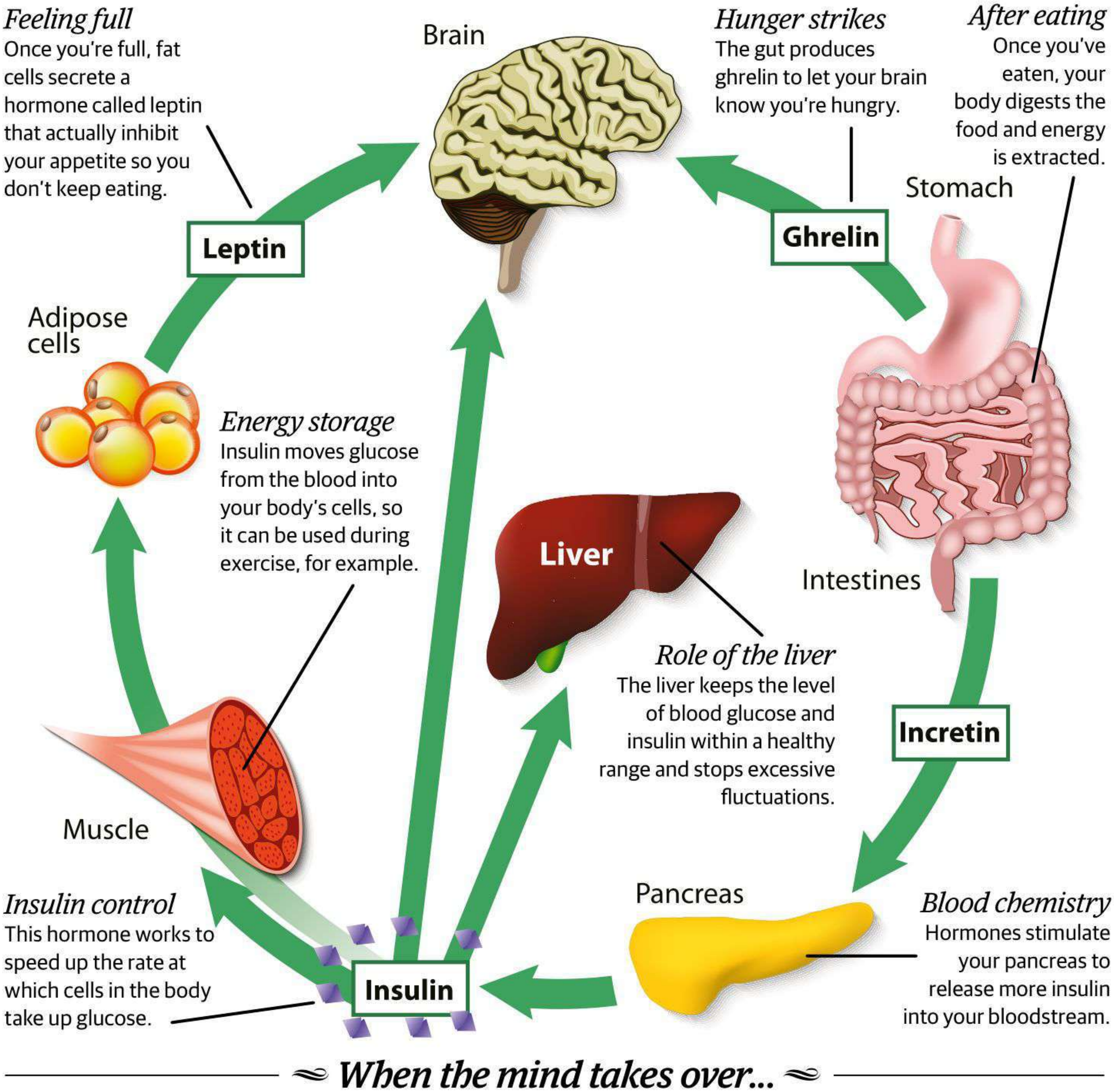
Hungry hormones

Whether you're a bit peckish or totally ravenous, it's all down to the hormones in your system



When the mind takes over...

When our minds get involved in craving food, it's a whole different story.

There's not much nutritional value in a bacon sandwich or a donut, for example, so it's not a 'need' for a treat, it's a 'want'. This is because the very first time you experienced a donut, the mesolimbic centre of your brain (the region that processes pleasure) lit up, as the treat released chemicals known as opioids that bind with receptors in the brain. Triggering the release of dopamine, the feel-good hormone. It's actually the same one that is released when we fall in love!

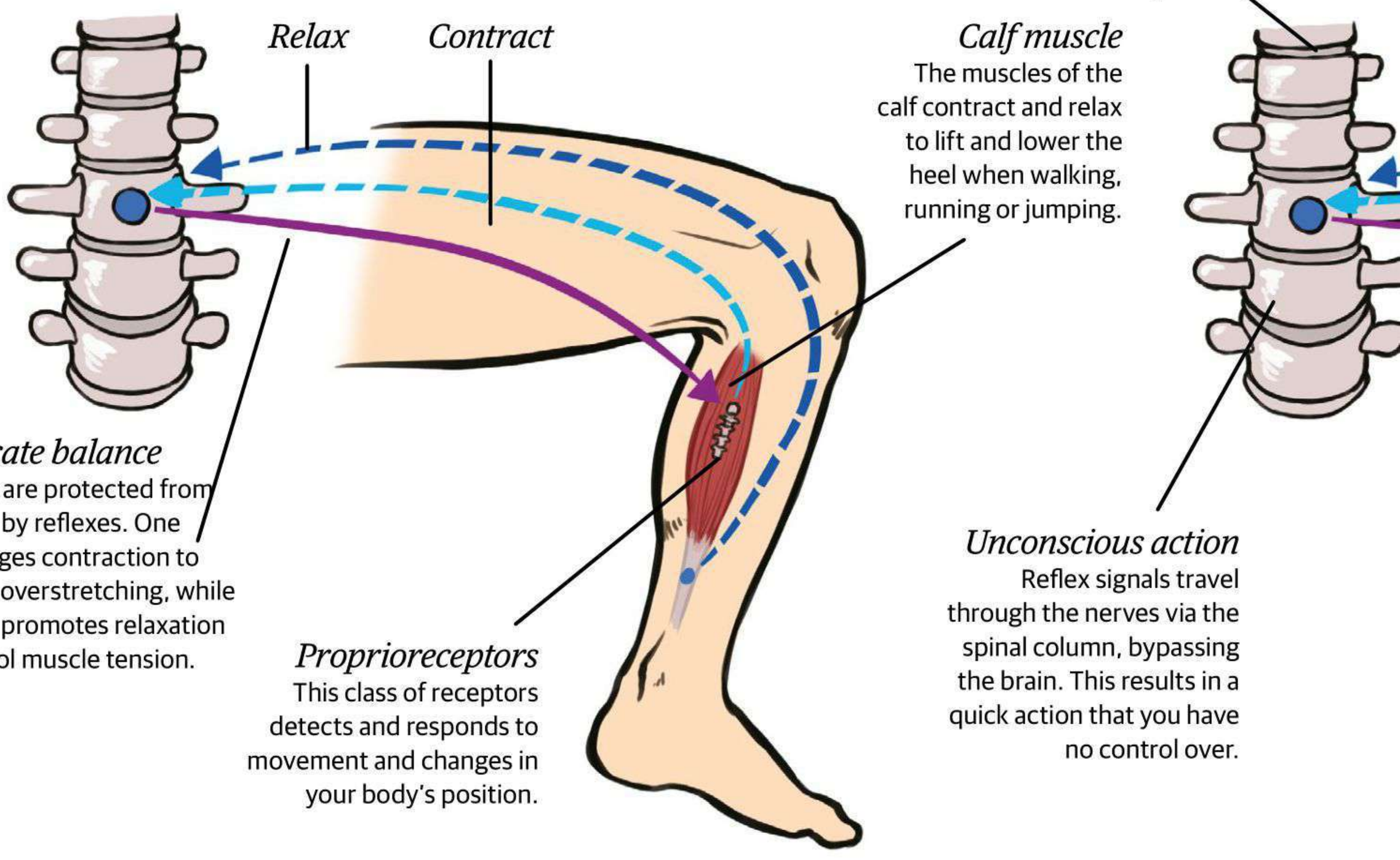
What are muscle cramps?

What causes these unexpected and painful spasms?

Cramp occurs when your muscles involuntarily contract very quickly and do not relax again straight away. These sudden spasms commonly affect the calves and last just a few seconds, but can persist for 15 agonising minutes or more. Normally, your calf muscles contract to raise your heels and relax to lower them, allowing you to walk, run and jump. However, during a cramp these muscles contract tightly and unexpectedly, leaving you unable to control them until the contraction subsides. The affected muscles will continue

What causes cramp?

The leading theory suggests that disrupted nerve signals may be to blame



to remain tense, tender and painful while they are refusing to relax.

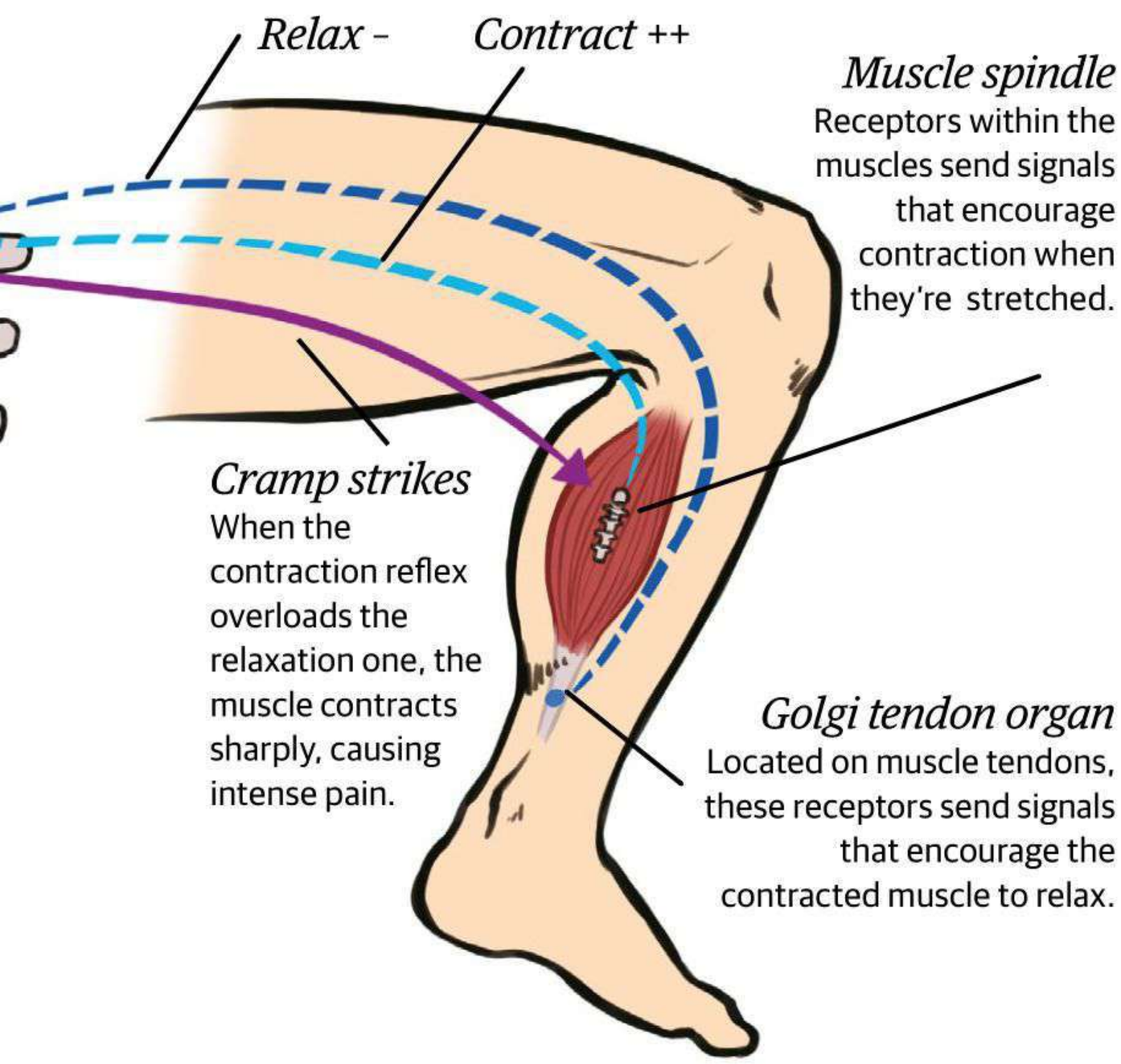
Despite being such a common experience, nobody knows exactly what causes these random contractions. It's thought that excessive strain on the muscles or a restriction in blood supply could be contributing factors, but one of the most prevalent theories is that cramps are actually caused by abnormal nerve activity.

Receptors within muscles and tendons constantly monitor the body's movement and position. These receptors send reflex signals to protect the muscles from potential damage. One reflex encourages muscle contraction, to prevent overstretching, while the other promotes relaxation to control tension. These reflexes are normally balanced, but can be disrupted so that the contraction signal overwhelms the relaxation one, resulting in the unexpected, intense and painful muscle spasm of cramp.

They are often associated with exercise, but according to the NHS, 75 per cent of leg cramp cases occur during sleep.

©Thinkstock

Above
Even elite athletes can be floored mid-stride by cramp



Types of cramp

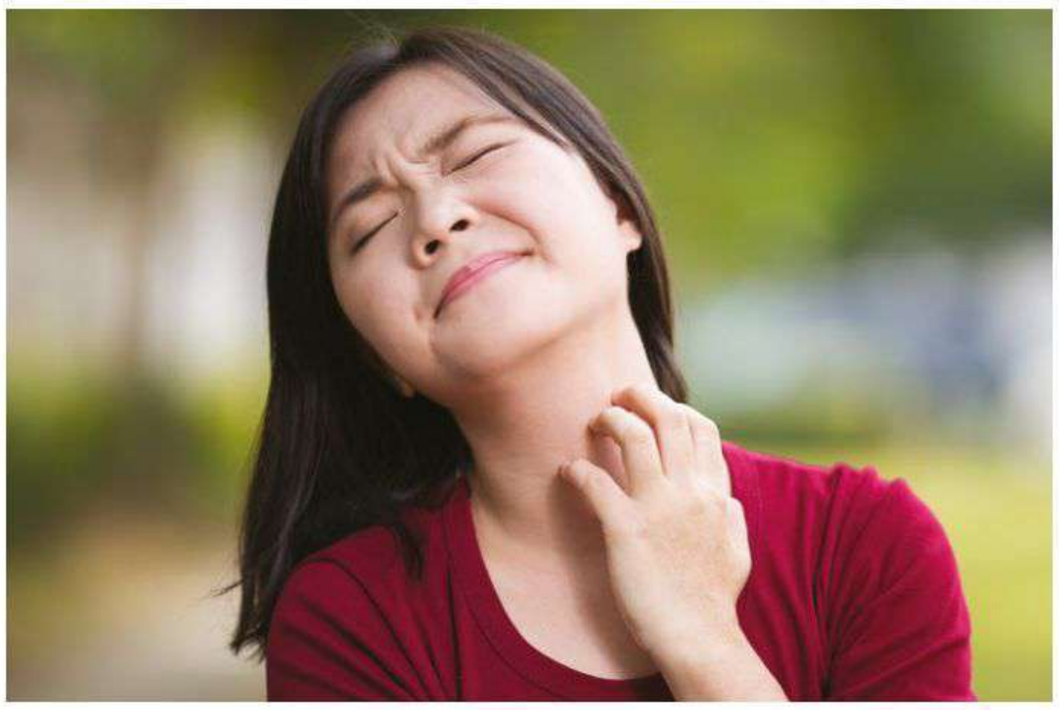
Apart from being an inconvenience, cramps are generally harmless. However, if they persist for more than 15 minutes, or reoccur regularly, they may be a symptom of an underlying problem.

Leg cramps are divided into two categories: idiopathic or secondary. Idiopathic leg cramps seemingly happen for no reason, like those that occur just as you're drifting off to sleep. Secondary leg cramps are related to pre-existing conditions or particular activities, such as infections, neurological disorders, strenuous exercise or dehydration. Pregnant women may also become vulnerable to cramps, as the weight of the growing foetus puts strain on their legs.

Can you get hives from stress?

Can relaxing help improve your skin?

Below
Hives are most often the result of a reaction to a range of allergens or irritants



Hives is a type of skin rash that is also known as nettle rash, weals, welts or urticaria. It is red, raised and itchy, and usually triggered by chemical messengers, like histamine. These signals are released in the skin in response to irritants and allergens, and work to increase the blood flow to the area. They make the blood vessels leaky, helping the immune system to get in and clear out whatever is causing the irritation. However, not all cases of hives have an obvious cause, and factors like emotional stress can sometimes be a trigger. Alcohol, caffeine and warm temperatures are also among the causes that can make the skin react in this way.

How does adding salt and sugar to food help to preserve it?

What's the science behind these shelf life-extending substances?

Below
The sugar used to make jam helps to lower the water content of the fruit

We've used salt and sugar to preserve foods since ancient times. Without this ingenious idea we wouldn't have jam, bacon or other cured meats. Most commonly, it works using a process called osmosis. To balance out its own salt or sugar content with that of the food, the added salt or sugar draws out water molecules from the food's cells and inserts its own molecules instead. This makes it more difficult for microbes such as bacteria to grow.

Can loud noises give you a headache?

Is it a good idea to turn down your headphone volume?

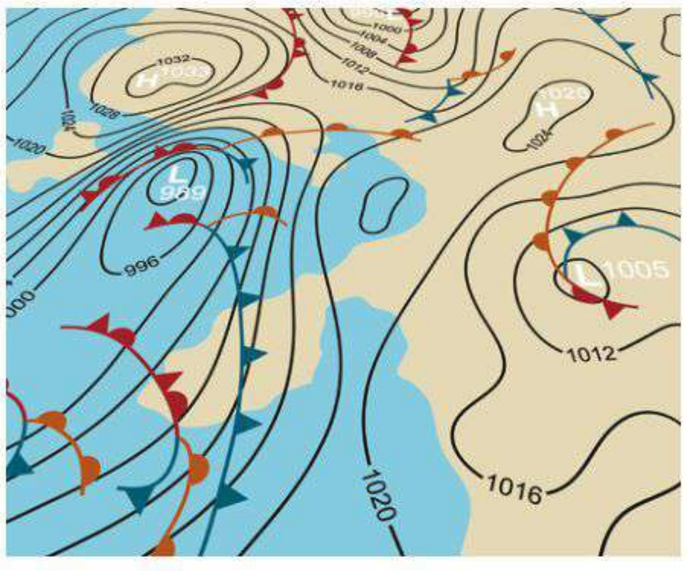
Noise has been shown to cause headaches. Research indicates that listening to loud music for a few hours a day can give you a sore head. For some, loud noises can cause headaches even if they don't usually get them. Noise is also a possible trigger for sufferers of migraines or tension headaches. However, we're not entirely sure why this is. It might be that loud noise causes blood vessels in the face to dilate. Noise-induced headache sufferers could also have problems in the way that their brains suppress sound.

Right
Loud noises are a real headache trigger for some people

Why is the weather forecast so often wrong?

Should we cut our weather people more slack?

Below
Weather predictions are made using vast quantities of data

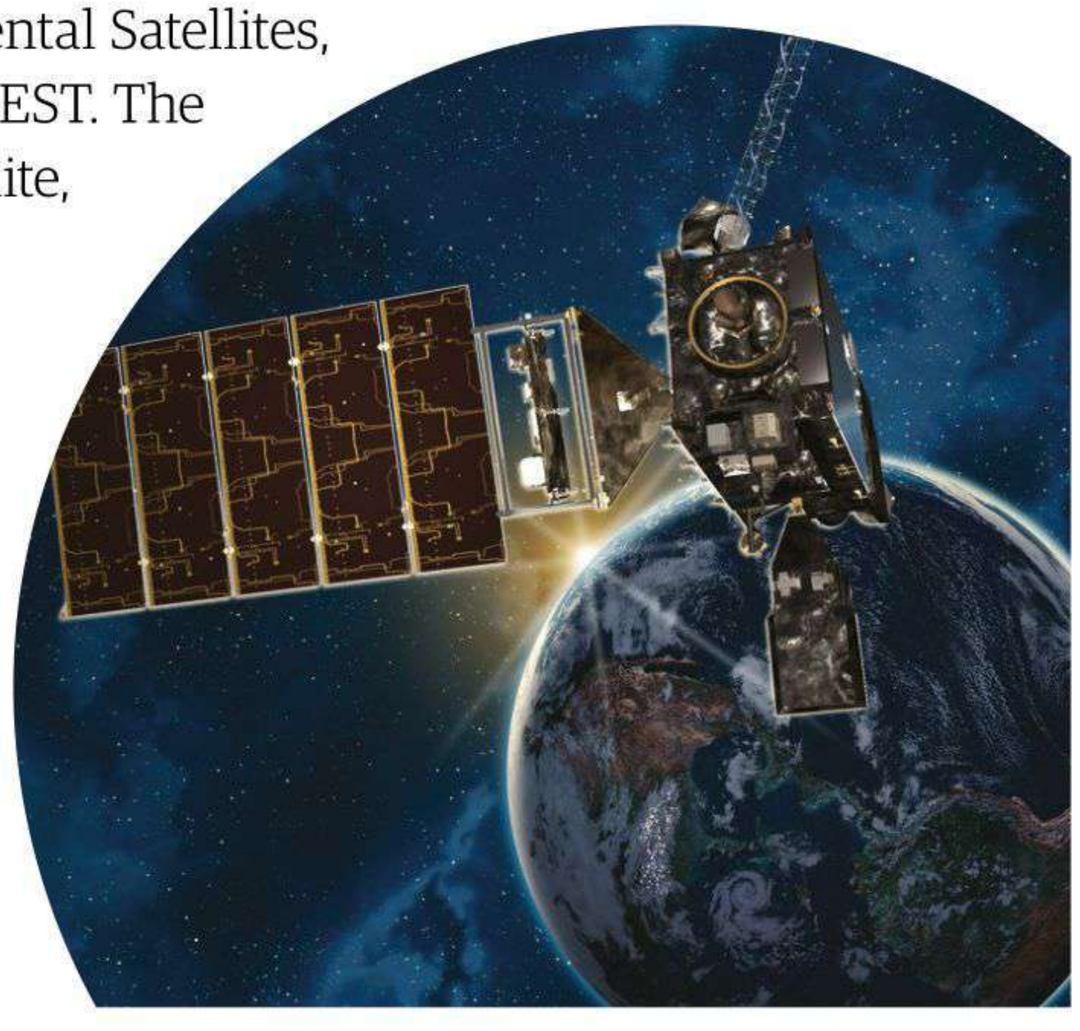


Weather forecasting is based on observations of Earth's atmosphere, the planet's surface and the oceans. Every day, the UK's Met Office takes over 500,000 measurements from around the world at various altitudes. Supercomputers use these to make models of what the atmosphere is currently doing, and predict what it might do next, but it's not an exact science. Improvements in tech mean that the four-day forecasts produced today are as accurate as the one-day forecasts of 30 years ago. And temperature predictions for the next day are right to within two degrees Celsius 87 per cent of the time.

What are meteorological satellites?

The spacecraft keeping a watchful eye on Earth to help us predict the weather

Weather forecasting isn't just handy for letting you know if you need an umbrella, it can also help save lives by providing early warning of devastating storms and floods. To be able to accurately predict these events, forecasters need to constantly monitor the Earth's surface and atmosphere, and they can do this thanks to a vast network of meteorological satellites flying through space. There are two main types: geostationary and polar-orbiting satellites, which work together to monitor the planet from every angle. Currently watching North and South America and the Eastern Pacific are the Geostationary Operational Environmental Satellites, GOES-EAST and GOES-WEST. The current GOES-EAST satellite, GOES-13, is actually set to retire after ten years of service. Its new replacement, GOES-R, will be able to provide 50 times more information, helping forecasters predict the weather more accurately than they ever have before.



Right
GOES-R is to be renamed GOES-16 after launch

Next-generation weather satellite?

How GOES-R will monitor the weather in amazing detail

Solar array
Five separate solar panels will deploy into a single, rotating wing to provide electricity for the satellite's instruments.

Geostationary Lightning Mapper (GLM)
By monitoring the presence of lightning, GLM will provide early predictions of storms and other severe weather events.

Advanced Baseline Imager (ABI)
ABI will measure the visible and infrared light reflected by the Earth to monitor clouds, atmosphere and surface.

Solar Ultraviolet Imager (SUVI)
SUVI will create regular images of the Sun to help us forecast space weather that could disturb Earth's magnetic field.

Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS)
This instrument monitors the Sun's electromagnetic radiation to detect solar flares that can even interrupt communication and navigation systems.

Space Environment In-Situ Suite (SEISS)
Four sensors monitoring proton, electron and heavy ion fluxes in space will highlight any radiation hazards to astronauts and spacecraft.

Star tracker
By pinpointing its location using the position of the stars, the satellite's thrusters can manoeuvre in orbit.

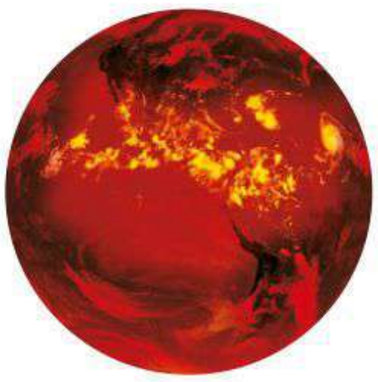
Unique Payload Services (UPS)
Transponders communicate with other satellites for more geographically complete monitoring.

Antennas
The data collected by GOES-R will be sent back to Earth for processing via a series of antennas.

Magnetometer
Able to detect charged particles that can be dangerous to spacecraft.

Combined
Combing visible and infrared data helps show Earth's features and their temperatures in greater detail.

Visible
The clouds reflect more light and so appear brighter than the land and sea.



Infrared
Features with hotter temperatures appear darker whereas cold areas are bright.

What are constellations?

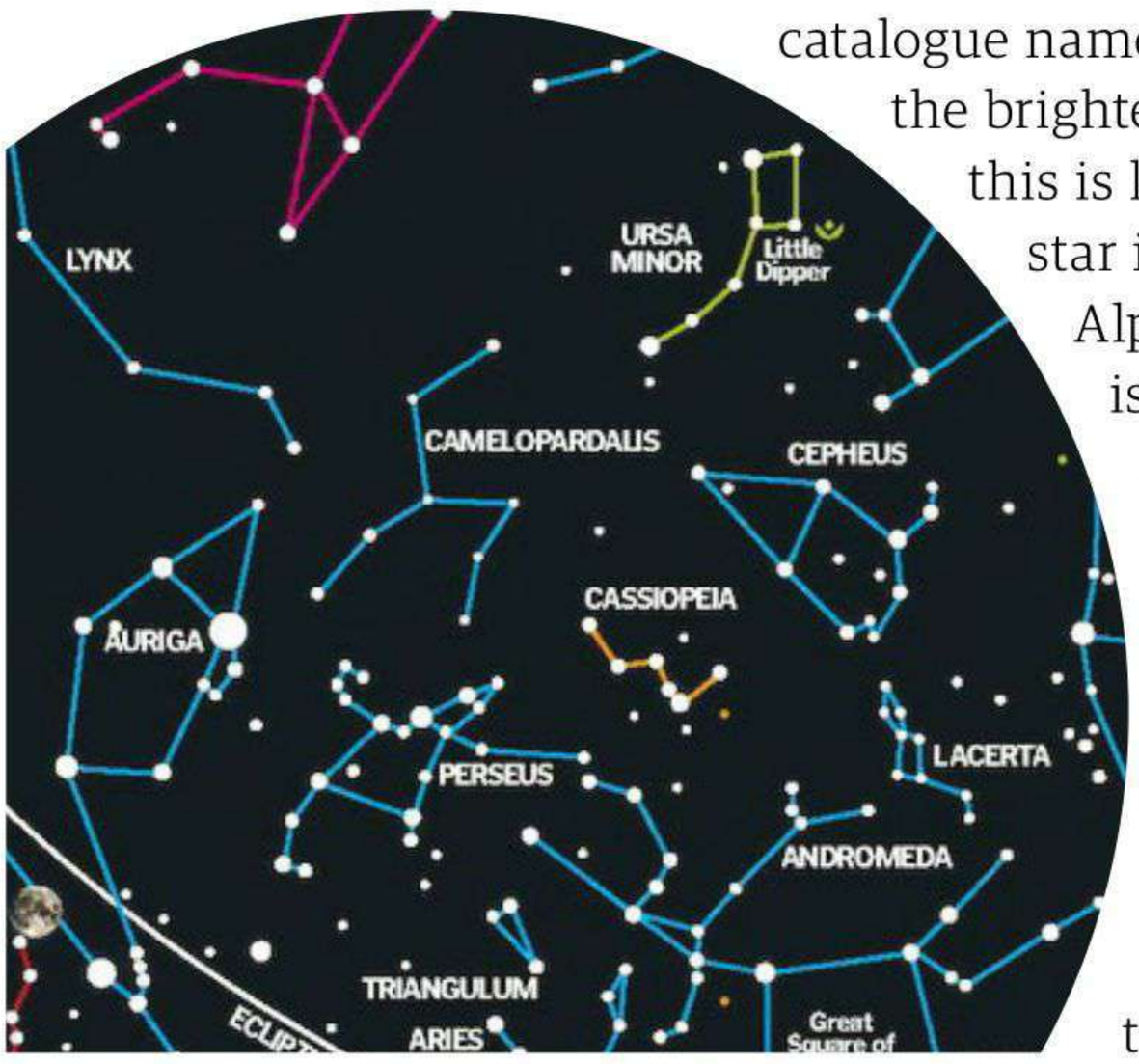
Without making patterns, our night sky would be a confusion of stars

While we know that the stars are many light years away, and all at different distances, astronomers still put them into groupings called constellations. These are named after the characters, animals and objects they resemble.

The constellations help us make sense of the night sky. Without them, it would be a chaotic sprinkling of stars, constellations give astronomers a quick and visual way of getting their bearings in the cosmos.

There are 88 official constellations and these provide the catalogue names of the stars. For example, Deneb is the brightest star in the constellation Cygnus, so this is known as Alpha Cygni. The brightest star in Boötes is Arcturus, so it is also called Alpha Boötis. The Andromeda galaxy is in the constellation of Andromeda, so seasoned stargazers will know the rough area of the sky in which to look.

You'll probably have heard of the Zodiac constellations - Capricorn, Aquarius, Pisces and so on, plotted along the path that the Sun moves through each year. Your sign is the constellation that the Sun was in at the time of your birth.



Below
There are 88 official constellations

Distances to the stars of Orion

Orion might look like a flat blanket of stars, but its components are spread over hundreds of light years

Betelgeuse

Betelgeuse is a red supergiant that could explode as a supernova any day, and is about 640 light years away.

Orion nebula

The nebula forms the fuzzy tip of the 'sword' hanging from Orion's belt of three stars. It is a giant cloud of gas forming new stars and is 1,344 light years away.

Saiph

At the lower-left 'knee' of Orion, Saiph is 650 light years away. It is a large star that, like Betelgeuse and Rigel, will one day blow up in a supernova.

Bellatrix

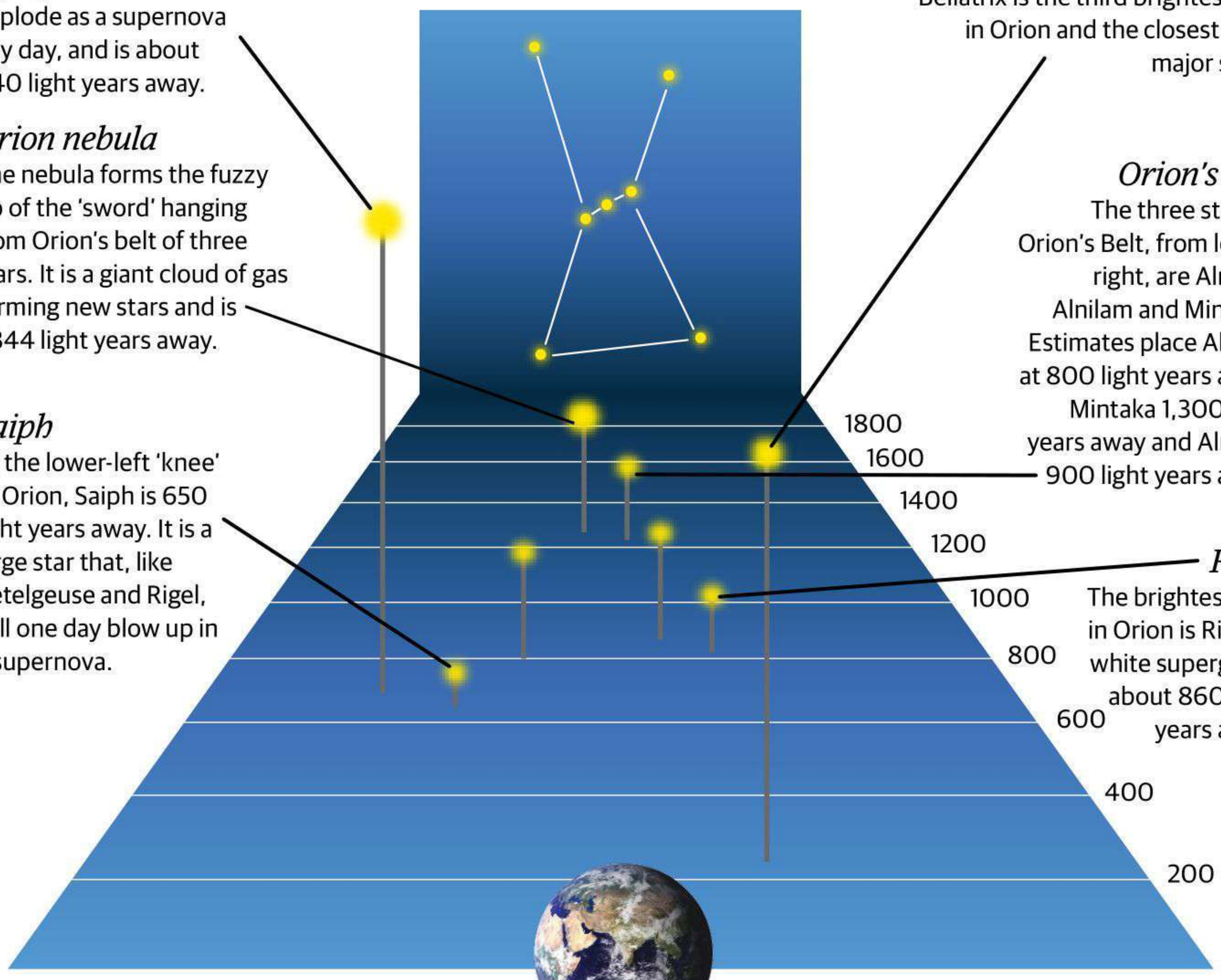
Just 250 light years away, Bellatrix is the third brightest star in Orion and the closest of its major stars.

Orion's Belt

The three stars in Orion's Belt, from left to right, are Alnitak, Alnilam and Mintaka. Estimates place Alnitak at 800 light years away, Mintaka 1,300 light years away and Alnilam 900 light years away.

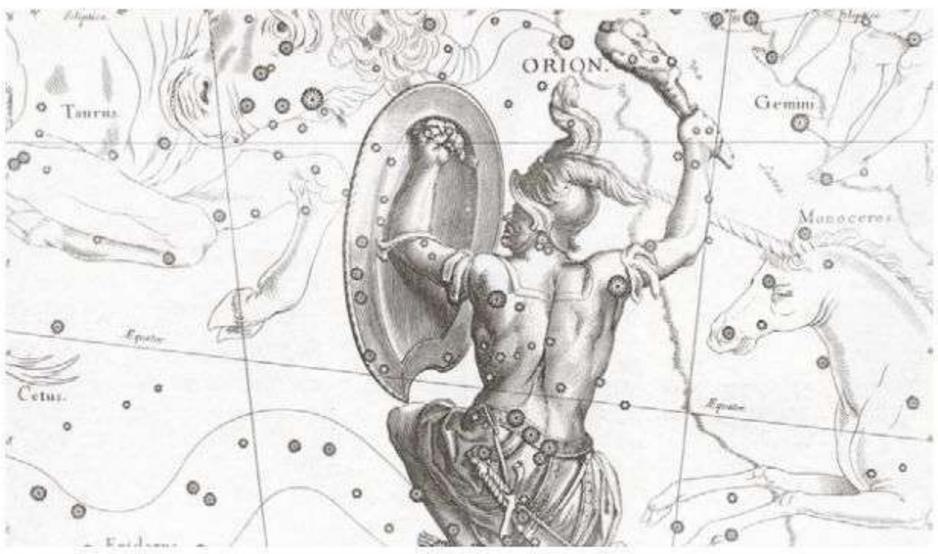
Rigel

The brightest star in Orion is Rigel, a white supergiant, about 860 light years away.



This diagram illustrates the distances of each of Orion's stars, measured in light years

Origins of constellations



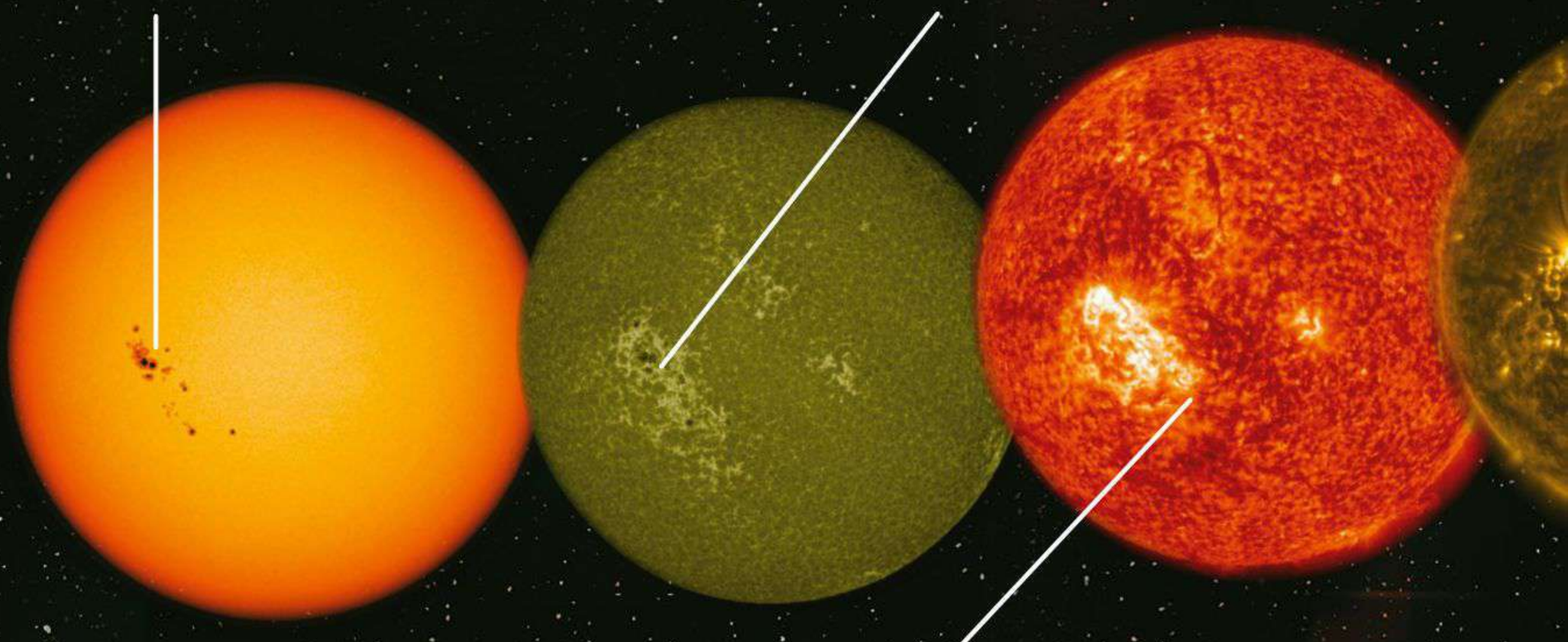
Civilisations going back to ancient times are thought to have charted the constellations. At first, these patterns of stars were used for astrological predictions and navigation, as well as for communication among astronomers. However, as the modern field of astronomy developed, it was soon discovered that different culturally nominated constellations made communication tricky. To solve the problem, the IAU divided the sky into 88 different constellations between the Northern and Southern Hemisphere and gave them names that are now universally accepted.

Why does the Sun look different in extreme ultraviolet?

Discover the different faces of the Sun when they are viewed at different wavelengths

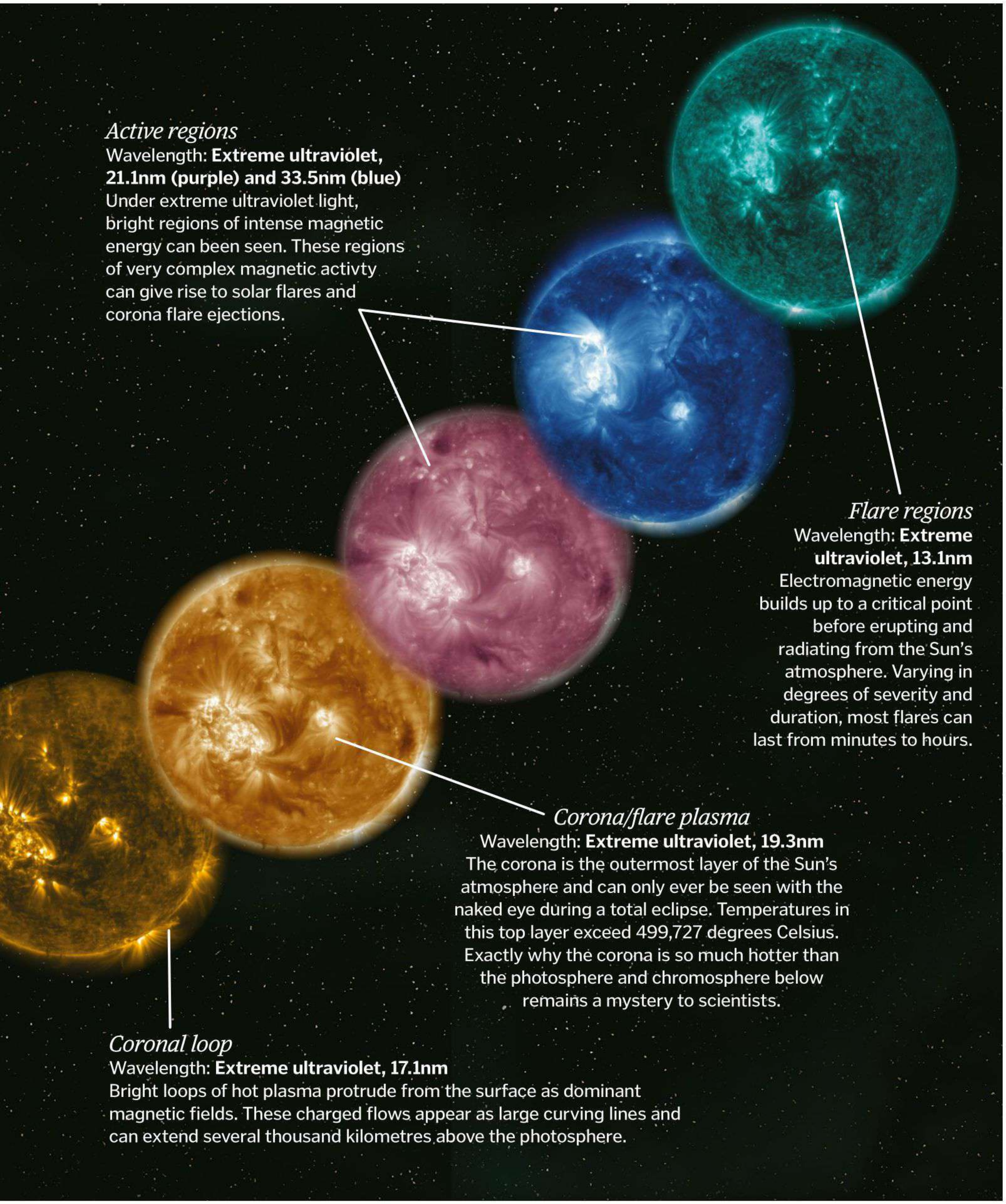
Sunspots
Wavelength: **Visible light, approx. 400–700nm**
These cooler, dark areas are the result of a disturbance in the magnetic field on the Sun's surface. They can reach temperatures of around 3,500 degrees Celsius and enormous diameters of up to80,000 kilometres.

Upper Photosphere/Transition region
Wavelength: **Ultraviolet, 160nm**
Here, the Sun's atmosphere appears somewhat granulated. The temperature of the photosphere can range from around 3,700 to 6,200 degrees Celsius; the temperature increases closer to the core.



Transition region/ Chromosphere
Wavelength: **Extreme ultraviolet, 30.4nm**
Between 400 and 2,100 kilometres from the Sun's surface, the chromosphere can range from 3,700–7,700 degrees Celsius. Unlike the photosphere, the temperature increases further away from the surface.

Extreme ultraviolet Sun



Active regions
Wavelength: **Extreme ultraviolet, 21.1nm (purple) and 33.5nm (blue)**
Under extreme ultraviolet light, bright regions of intense magnetic energy can been seen. These regions of very complex magnetic activty can give rise to solar flares and corona flare ejections.

Flare regions
Wavelength: **Extreme ultraviolet, 13.1nm**
Electromagnetic energy builds up to a critical point before erupting and radiating from the Sun's atmosphere. Varying in degrees of severity and duration, most flares can last from minutes to hours.

Corona/flare plasma
Wavelength: **Extreme ultraviolet, 19.3nm**
The corona is the outermost layer of the Sun's atmosphere and can only ever be seen with the naked eye during a total eclipse. Temperatures in this top layer exceed 499,727 degrees Celsius. Exactly why the corona is so much hotter than the photosphere and chromosphere below remains a mystery to scientists.

Coronal loop
Wavelength: **Extreme ultraviolet, 17.1nm**
Bright loops of hot plasma protrude from the surface as dominant magnetic fields. These charged flows appear as large curving lines and can extend several thousand kilometres above the photosphere.

What is the Fermi paradox?

A question with no clear answer

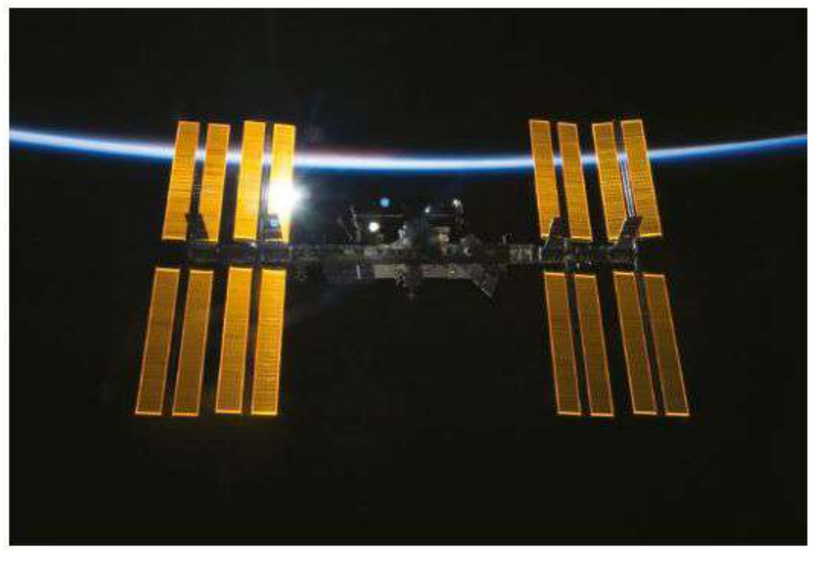
Below
The universe is thought to hold billions of Earth-like planets capable of supporting life

The Fermi paradox is a question posed by physicist Enrico Fermi. The odds are that our vast universe contains billions of Earth-like planets that could support life. Many are far older than Earth, and should have allowed advanced civilisations to emerge with incredible technology, including interstellar travel and communications. Statistically, we should have already made contact with advanced alien civilisations, but we haven't. Fermi's question was: "Where is everybody?" Space scientists have spent decades debating this without coming up with a definitive answer. Maybe interstellar travel is impossibly difficult, or perhaps the aliens have deliberately decided not to make contact with us. Or maybe we are simply alone in the universe!

What happens to waste from the Space Station?

What do astronauts do with their rubbish?

The next time you see a shooting star, it could be human excrement. Astronauts on the International Space Station flush their poo out into space, where it orbits Earth before burning up in the atmosphere as a shooting star. NASA astronaut Scott Kelly produced 80 kilograms worth of smelly shooting stars during his recent year-long stay on the Space Station! Regular rubbish is brought back down to Earth on board supply vessels that stop at the ISS.



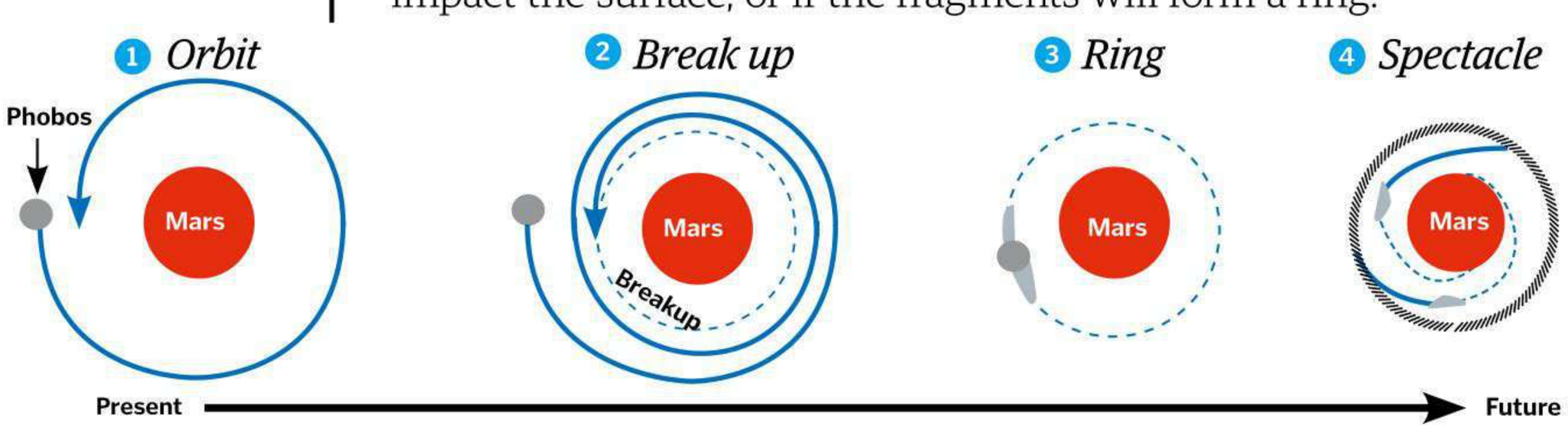
Right
Astronauts flush their waste out into space, where it orbits Earth for a while

Will Mars get rings?

One of the Red Planet's two moons is on a death spiral towards it

One of Mars' moons, Phobos, is destined to die. In about 10 to 50 million years, scientists expected to break apart and possibly form a ring around Mars. It is slowly falling towards the Red Planet due to the gravitational pull. It orbits just 6,000 kilometres above the surface and is getting closer by 1.8 centimetres a year. Eventually, the weakest, most damaged material will be pulled from the moon. Scientists aren't sure if it will then fall towards Mars and impact the surface, or if the fragments will form a ring.

Below
How Phobos might break apart in Martian orbit

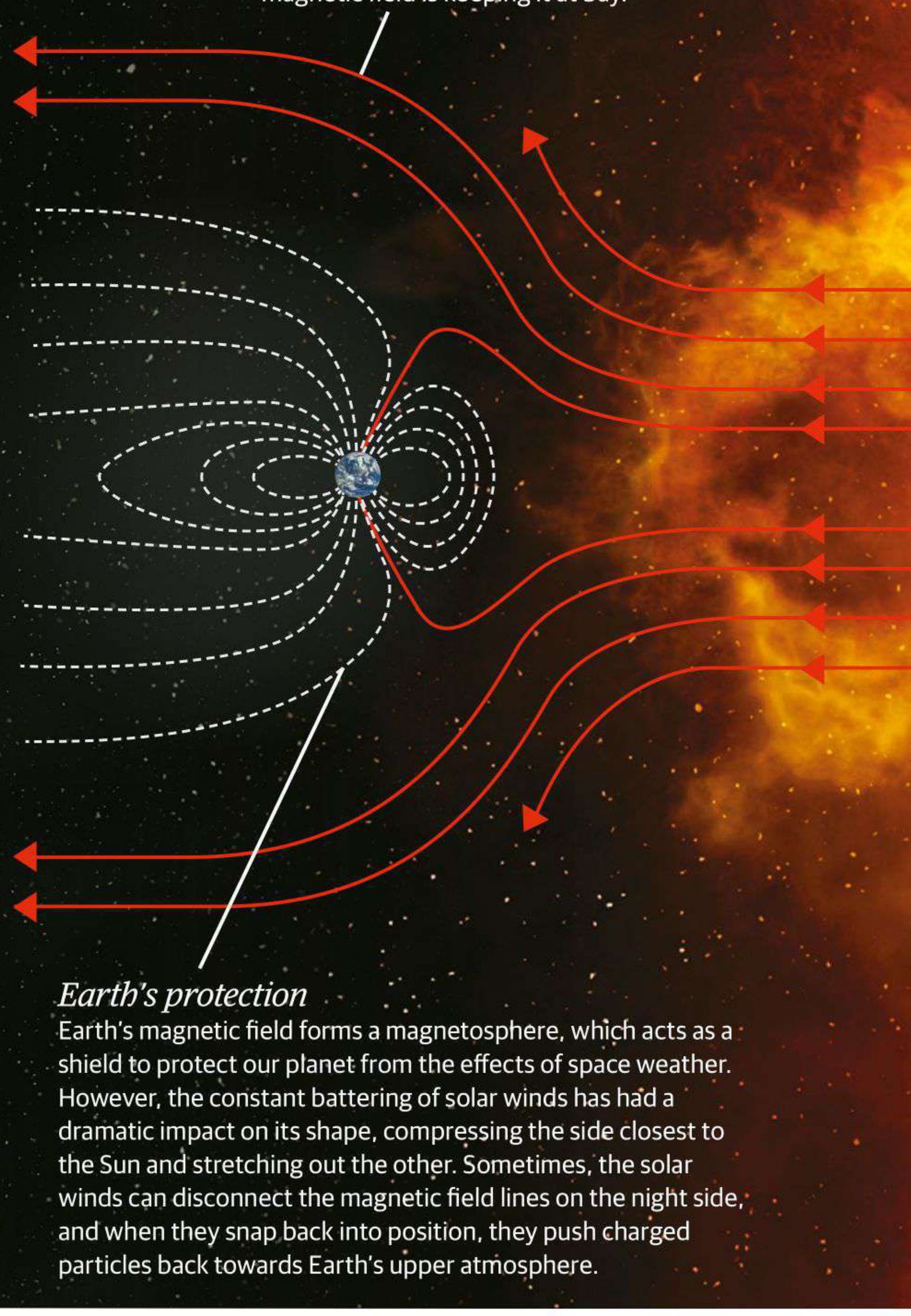


©Thinkstock, NASA

What is weather like in space?

Get the forecast for the Sun's explosive activity and how it affects us on Earth

The Sun, and the vast vacuum of space surrounding it, may seem pretty peaceful to us on Earth, but it is actually alive with violent activity. Although you might not hear about it on television forecasts, it's the source of a variety of space weather, and there are some very important reasons why we should be aware of it. Throughout its 11-year solar cycle, the big ball of hot plasma at the centre of our Solar System bombards our planet with solar winds. During periods of peak activity, this can disrupt many of the technological systems we rely on for communication, navigation and more. Read on to discover how...



Solar wind

Streams of charged particles called plasma are constantly escaping the surface of the Sun, as the star's powerful gravity fails to contain them. Known as solar wind, it can reach speeds of up to 800 kilometres per second as it hurtles towards Earth, where it continuously batters our planet's magnetic field. Solar wind is so powerful that it is believed to have stripped away the atmospheres of many other planets, such as Mercury, but Earth's relatively strong magnetic field is keeping it at bay.

Earth's protection

Earth's magnetic field forms a magnetosphere, which acts as a shield to protect our planet from the effects of space weather. However, the constant battering of solar winds has had a dramatic impact on its shape, compressing the side closest to the Sun and stretching out the other. Sometimes, the solar winds can disconnect the magnetic field lines on the night side, and when they snap back into position, they push charged particles back towards Earth's upper atmosphere.

Solar flares

When twisting magnetic field lines in sunspot regions cross and reconnect with one another, they cause massive explosions called solar flares. The energy released is the equivalent of millions of 100-megaton hydrogen bombs exploding at the same time, sending huge amounts of radiation out into the Solar System. The radiation emitted spans across the entire electromagnetic spectrum, from radio waves to X-rays and gamma rays, and travels at the speed of light to reach Earth in just eight minutes.

Coronal mass ejections

The magnetic field lines that produce solar flares sometimes become so twisted that they actually snap and reconnect at other points. The gaps that form can no longer hold plasma on the Sun's surface, and release billions of tons of it into space as a 'coronal mass ejection'. Their speed can vary greatly, meaning they can reach Earth in a matter of hours or days, and when they do their own magnetic field slams into Earth's to generate geomagnetic storms.

Sunspots

Magnetic field lines breaking through the Sun's surface create dark regions known as sunspots. As heat is inhibited from rising up from the solar interior, these regions are comparatively cooler than the rest of the Sun's surface, but still reach scorching temperatures of around 3,500 degrees Celsius. Sunspots are usually found near to the Sun's equator and are the source of most extreme space weather. The number of them varies throughout the 11-year solar cycle, creating periods of peak activity.

Above
A Hubble Space Telescope image of one of the galaxies measured in the June 2016 survey to estimate the expansion of the universe

How fast is the universe expanding?

How can scientists tell just how fast the universe is changing size?

In 1929, American astronomer Edwin Hubble announced a truly ground-breaking discovery: the universe was expanding. By observing the light from distant galaxies, Hubble found that their wavelengths were stretched out (red shift), and the further away the galaxies were, the more red shifted the light was. This observation only made sense if the universe was expanding. The extent of a galaxy's red shift indicates the speed at which it is moving. Hubble found that a galaxy's distance and speed, and therefore the rate of the expansion of the universe, were directly linked by a constant value, which is known as the Hubble constant.

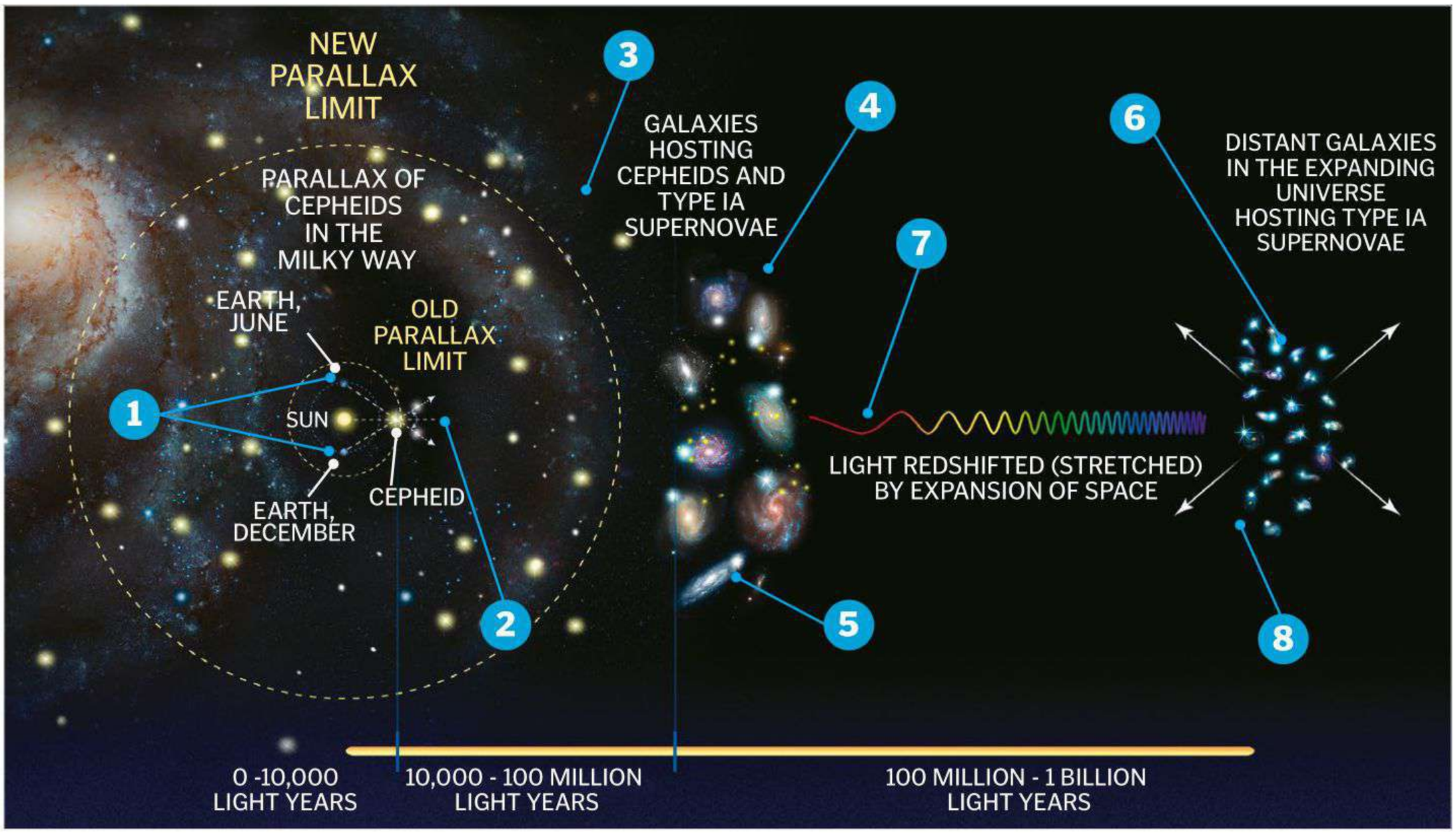
In 1929, the constant's value was 500 kilometres per second per megaparsec (one megaparsec is approximately 3.26 million light years), but this figure was based on limited data.

In 2016, scientists were able to make the most precise estimate yet: 73.2 kilometres per second per megaparsec. This more accurate data led to the discovery that the universe is in fact expanding between five and nine per cent faster than previously expected. No human being has ever travelled more than 400,171 kilometres from the surface of the Earth, little more than a couple of days away. People have spent months on the ISS, but home is just below and always in sight – travelling to other planets will be very different.

Astronauts are already thoroughly screened to ensure that they are able to withstand the stresses and challenges of space travel, but extra precautions are now also being taken before a crew makes this bold leap into the unknown. On Earth, trainee crews are simulating the isolation of long-term space travel in specially designed habitats to make sure they are up to the challenge that lies ahead.

Finding the Hubble constant

The only way to prepare for isolation is to experience it



1 Hubble observations

The Hubble telescope is used to make two observations of the same Cepheid variable stars within our own galaxy, six months apart.

2 Parallax

Using the difference in the two measurements of the apparent position of these stars, astronomers can use geometry to determine their distances from the Sun.

3 Brightness configuration

Once the stars' distances are known, it is possible to work out their true brightness. This information can be used to determine how far away more distant Cepheid variables are.

4 Nearby galaxies

Astronomers look for galaxies containing both Cepheid variables and Type Ia supernovae. By comparing the brightness of the two, astronomers can figure out the true brightness of the explosion.

5 Galactic measurements

Knowing the supernova's true brightness helps astronomers determine how far away it is. Type Ia explosions always give off a similar amount of light.

6 Distant galaxies

Supernovae are bright enough to be seen over much greater distances, so astronomers can compare the apparent versus the actual brightness of Type Ia supernovae to determine their distance.

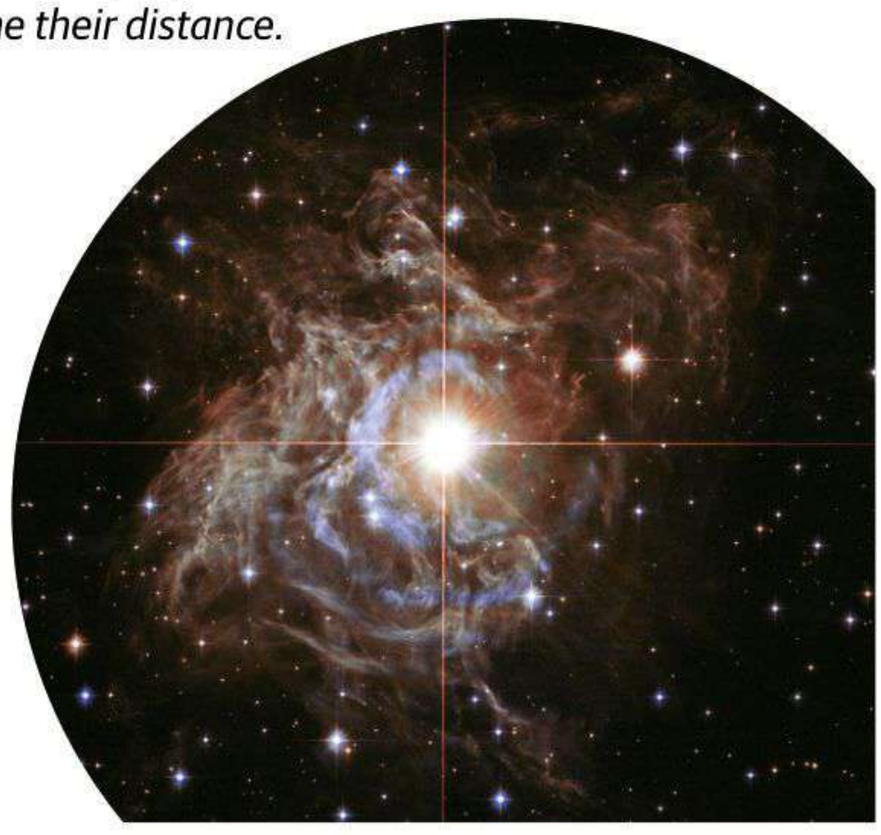
7 Red shift

The wavelength of light from distant galaxies gets stretched due to the expansion of the universe.

8 Expansion

The universe's expansion can be calculated using the distance and red shift measurements from distant galaxies.

Below
A Hubble Space Telescope image of one of the galaxies measured in the June 2016 survey to estimate the expansion of the universe



How do astronauts train for space?

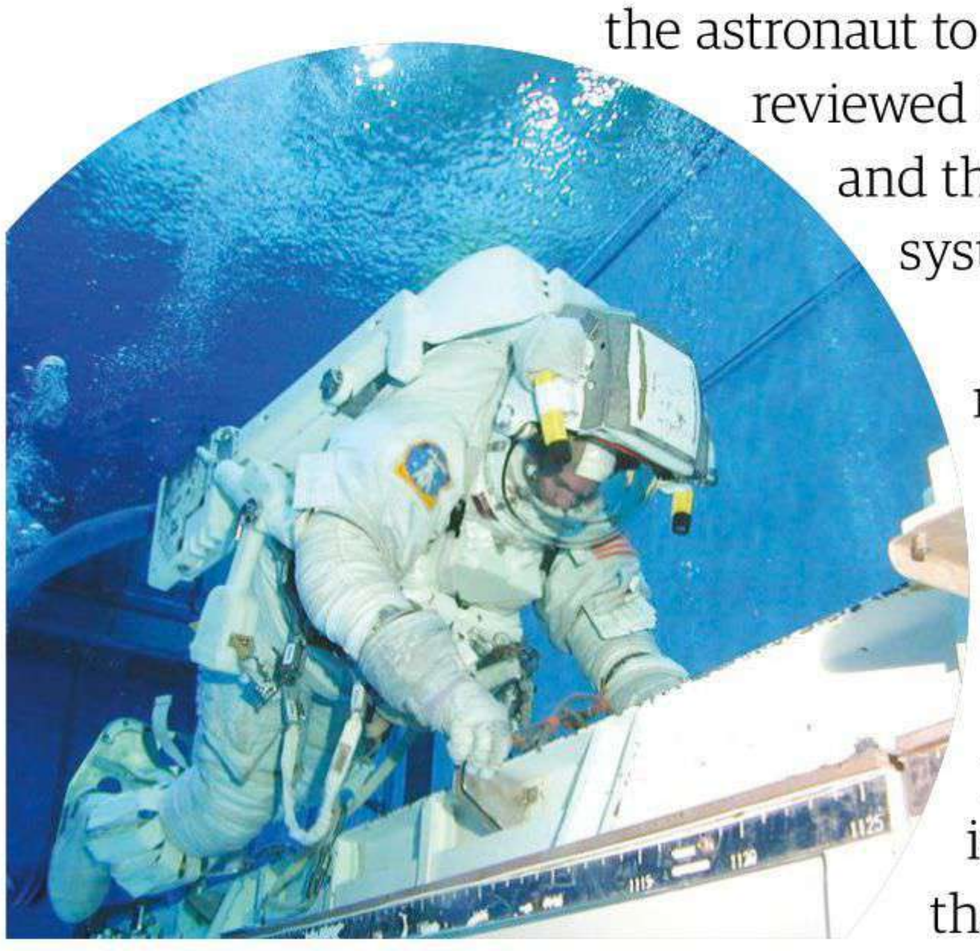
The best place on Earth to prepare for zero gravity is a swimming pool

When an astronaut prepares for a mission to the International Space Station, they must practise the tasks that they'll be carrying out in space. However, in order to make the training as realistic as possible, the microgravity they'll encounter outside our planet's atmosphere needs to be mimicked here on Earth.

NASA has an ingenious way of replicating space's unique environment on our home planet – it has placed a large-scale mock-up of the ISS in an enormous swimming pool. The American space agency calls this 12-metre (40-foot) deep pool the Neutral Buoyancy Lab (NBL) and astronauts have been training here since 1996.

Astronauts undertake six-to-eight-hour underwater sessions on a daily basis. When it's time to begin training, a camera diver shadows the astronaut to capture everything that happens, so it can be reviewed later. Safety divers are also on-hand at all times and the astronaut is rigged up to various support systems for air, power and communications.

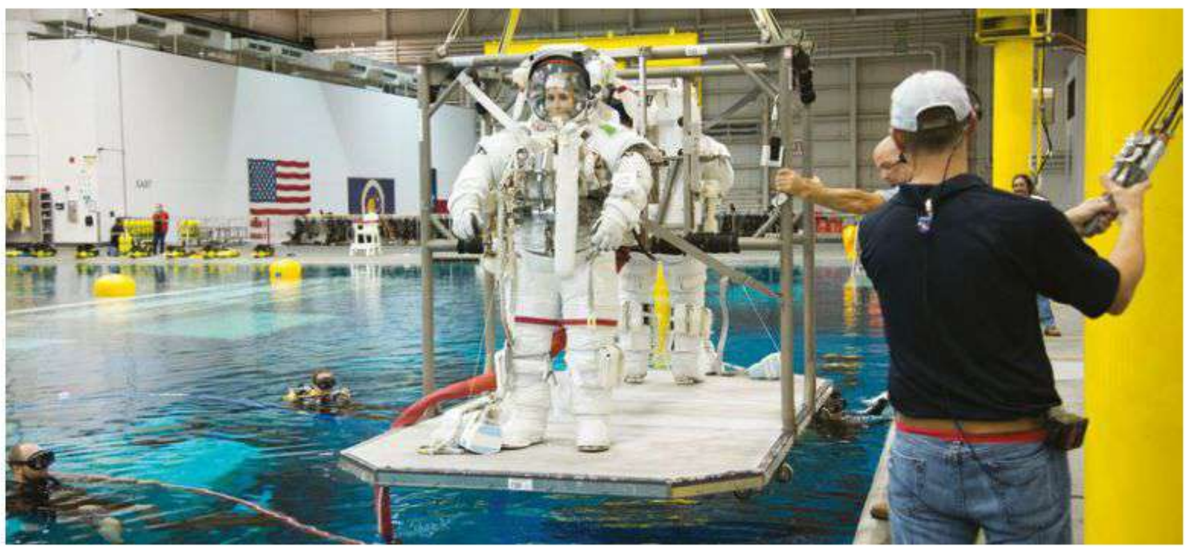
Underwater, the trainee astronaut is breathing nitrox air, which is comprised of 46 per cent oxygen. This increased oxygen concentration reduces the risk of decompression sickness. Long tethers also enable an astronaut to lock themselves onto handrails while they are practising a task. Everything they do underwater is a simulation of what they'll be doing onboard the ISS.



Below
In the Neutral Buoyancy Laboratory, astronauts train for up to eight hours a day underwater

Size does matter

An essential piece of clothing for space travel, each part of a spacesuit has an important job



Before getting in the water for a session in the Neutral Buoyancy Laboratory, an astronaut has to dress for the part. During the fitting for their space suit, there are 36 measurements taken of their bodies and 46 measurements of their hands, while plenty of padding inside the suit ensures they don't slip around. The end result is so heavy – weighing almost as much as two men – that several technicians are required to help the astronaut get suited and booted.

Pool-sized space environment

In the Neutral Buoyancy Laboratory, astronauts can get a taster of what working in space will feel like

Voluminous

The pool contains an enormous amount of water: 28 million litres (6.2 million gallons) – the same as ten Olympic swimming pools!

Neutral buoyancy

The water provides 'neutral buoyancy', so astronauts who are training neither rise nor sink, simulating the effect of zero gravity.

Hidden depths

The NBL is 61.6m (202ft) long by 31m (102ft) wide, but it still can't fit the entire ISS inside.

Life support

Astronauts are connected to the pool's life support systems that provide air, power and communications, by 26m (85ft) long tethers.

Sunken space station

A mock-up of the International Space Station's modules lies 12m (40ft) deep in the water.

Safety

In 115,000 hours of dives, there has never been an accident with an astronaut. They are supported by a team of safety divers and cameramen.

Breathing underwater

In order to avoid decompression sickness, astronauts in the pool need to breathe nitrox air that is 46 per cent pure oxygen.

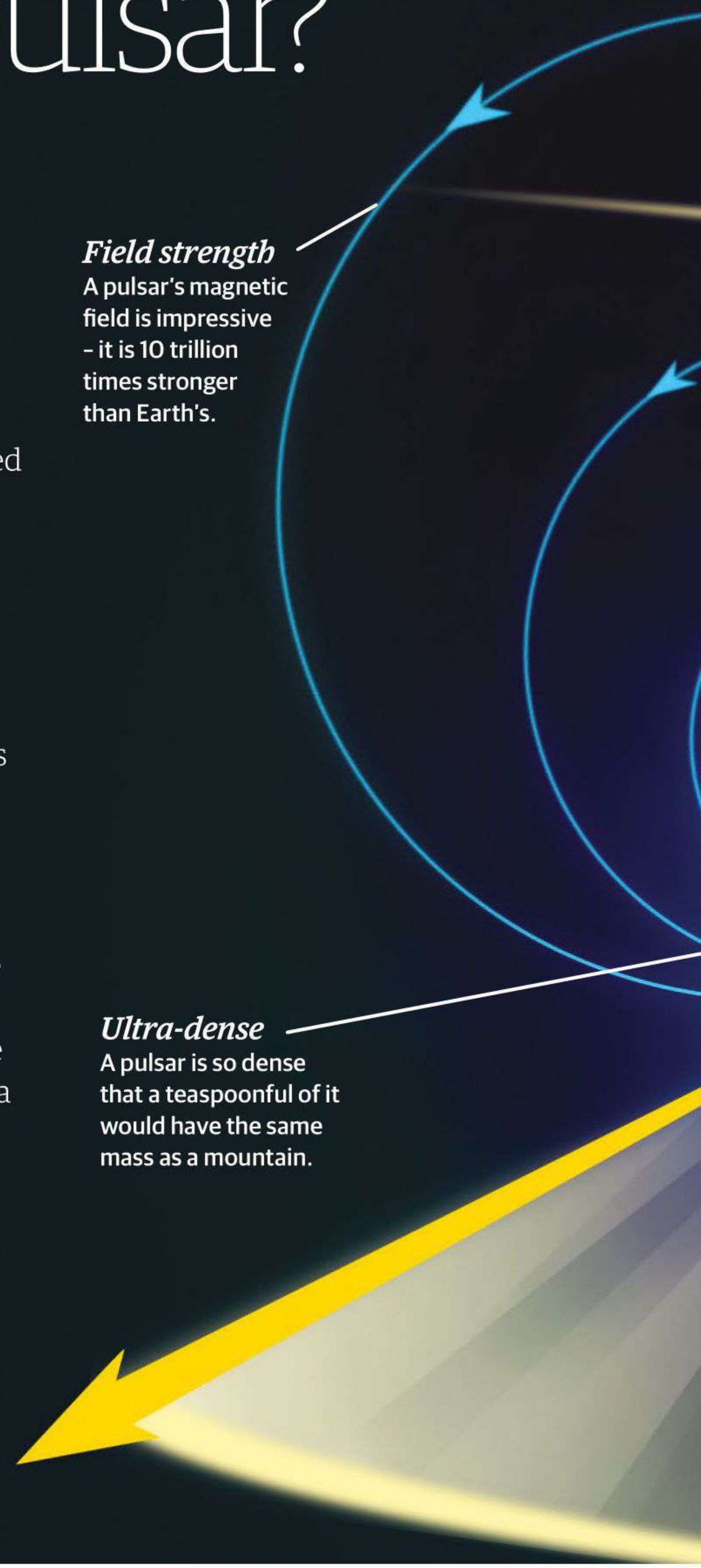
What is a pulsar?

The truth behind the 'alien beacons'

When pulsars were discovered in 1967 by Jocelyn Bell, nobody knew what they were. They were so mysterious that the first pulsar was half-jokingly nicknamed 'LGM-1', for Little Green Men. Today, however, we know that pulsars have nothing to do with aliens, but come from something just as dramatic. They are the rapidly spinning condensed cores of massive stars that have exploded as supernovae.

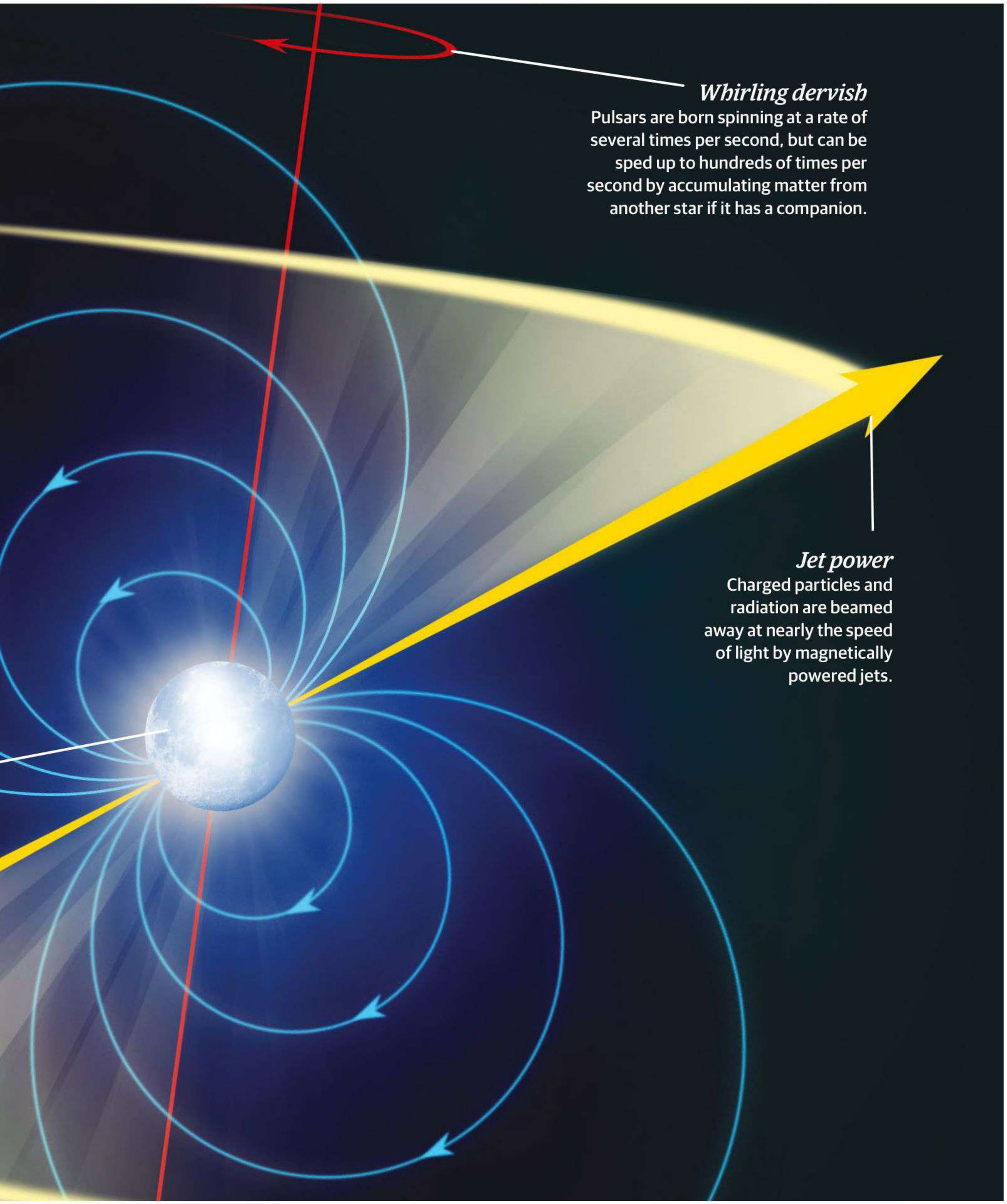
When a star greater than eight times the mass of our Sun reaches the end of its life, it stops generating energy from fusion power within its core. This causes the core to collapse into an object so dense that electrons and protons merge to form neutrons. The outer layers of the star quickly fall onto this collapsed core before a shock wave blows them back out, causing the star to explode. The core survives, however, as a 'star' of neutrons about 20 kilometres across.

This neutron star is highly magnetic and is born spinning. Its magnetic field funnels away charged particles along two jets bursting out from its magnetic poles. As the neutron star spins, these jets spin with it, flashing in our direction. We see them as a rapid sequence of light pulses – a pulsar.



Field strength
A pulsar's magnetic field is impressive – it is 10 trillion times stronger than Earth's.

Ultra-dense
A pulsar is so dense that a teaspoonful of it would have the same mass as a mountain.


Whirling dervish
Pulsars are born spinning at a rate of several times per second, but can be sped up to hundreds of times per second by accumulating matter from another star if it has a companion.
Jet power
Charged particles and radiation are beamed away at nearly the speed of light by magnetically powered jets.

What would happen if you used a laser pointer in space?

How far would the beam of light travel?

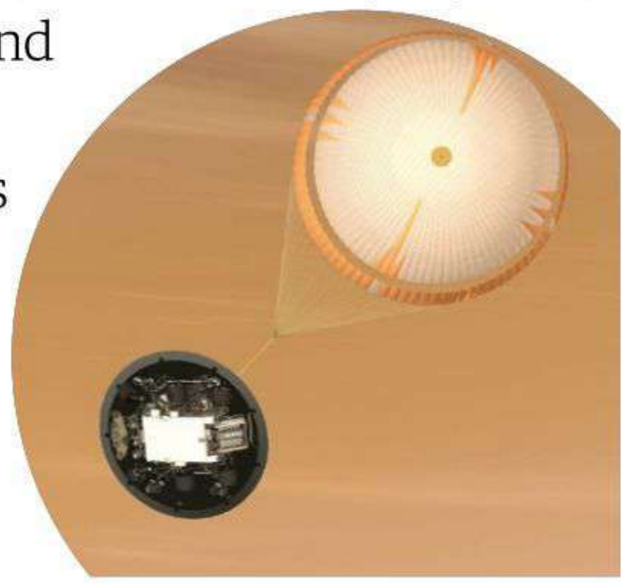
Below
Lasers fired in space will slowly disperse

Because photons of light carry momentum, a laser pointer floating in space would very gradually find itself pushed backwards in reaction to the beam of photons that are leaving the laser in the opposite direction – remember Newton's Third Law, which says that every action has an equal and opposite reaction. But you couldn't shine a laser pointer at, say, Pluto from Earth and expect to see a red dot appear on Pluto's surface. This is because laser beams disperse as they travel – even if you shine a laser pointer at a wall you can see the spot is wider than the beam leaving the laser.

How does a Mars landing differ from a Moon landing?

Discover the logistical differences between these two operation

There are three things that make landing on Mars different from landing on the Moon. The first is gravity – Mars' stronger gravity pulls spacecraft down faster. The second is that Mars has an atmosphere, whereas the Moon is airless. A spacecraft landing on Mars can use parachutes to slow its descent, but these wouldn't work on the Moon. The third is the greater distance, which affects the time it takes for signals and commands to reach the spacecraft from Earth.

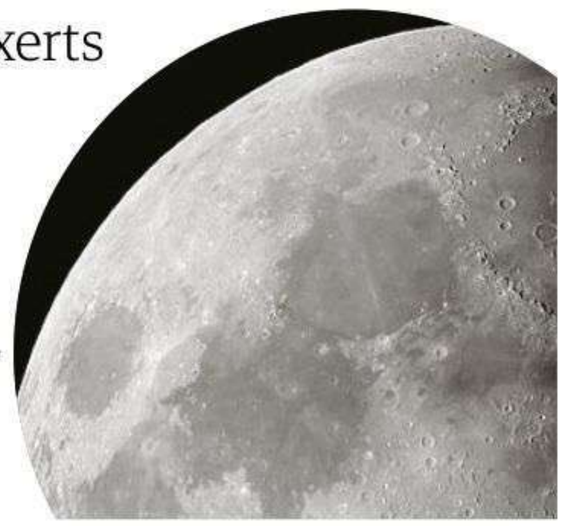


Right
Spacecraft landing on Mars can parachute down to the ground

Why is the Moon slowly moving away from us?

Discover how our Moon is moving away from Earth

The action of ocean tides is causing the Moon to gradually drift away from Earth. The Moon's gravitational pull on our planet's water creates a bulge on the ocean surface on the side of the Earth that is closest. This bulge in turn exerts a gravitational pull on the Moon. As the Earth rotates, the bulge moves forward in relation to the Moon. As a result, the Earth's rotation slows slightly, giving a little bit of energy to the Moon, pushing it away. Each year, the Moon edges about 3.78 centimetres further away.



Right
The Moon's drift is related to ocean tides

How can we see back in time?

When we look into space, we are actually looking into the past

If the Sun suddenly vanished, it would take a full eight minutes and 20 seconds for anyone to notice. This is because sunlight does not reach us instantly; it has to travel through space to get here, and that takes time.

The Moon is just over 384,000 kilometres away, so it takes a bit more than a second for its reflected light to reach us. Light from the Sun, at 150 million kilometres away, takes over eight minutes, while light from our next closest star, Proxima Centauri travels for four years. When light travels from our neighbouring galaxy, Andromeda, it takes an incredible 2.5 million years to reach us.

This effectively means that looking out into space is the equivalent to looking back in time. The Hubble telescope can see light released by ancient galaxies more than 13 billion years ago.

Below
When this light was emitted by Andromeda, our ancestors hadn't even learnt to use fire

©NASA

How do spacesuits work?

How this incredible device allows astronauts to survive the extremes

Spacesuits are an astronaut's life support system, providing them with oxygen, keeping them warm and protecting them from the vacuum of space. They provide communications with fellow astronauts and mission control, monitor their health and are sealed against the harsh environment outside. One of the most important parts of any space suit is the backpack: the Primary Life Support System, or PLSS. It's more than just an oxygen pack – it keeps the suit pressurised to prevent hypoxia, removes harmful carbon dioxide and cools the suit by pumping water around it. It also houses medical monitors and the communication equipment.

Inside the suit the astronaut wears a skin-tight Liquid Cooling and Ventilation Garment, which removes body heat through perspiration. Oxygen, carbon dioxide and water vapour are also sent back to the PLSS; the carbon dioxide is then removed by reacting with lithium hydroxide, producing lithium carbonate and water. The water vapour condenses and is also removed and stored in the pack, while oxygen is recycled back around the suit for the astronaut to breathe. If an astronaut on a spacewalk finds themselves drifting off into space, then the modern NASA spacesuits have a device called the Simplified Aid for EVA Rescue, which is composed of little jets that can fly them back to the space station.

Below
ESA astronaut Alexander Gerst tests his spacesuit at NASA's Johnson Space Center in Houston, Texas

Design details

An essential piece of clothing for space travel, each part of a spacesuit has an important job

Helmet with visor

The helmet features a visor coated with a thin layer of gold to filter out harmful solar rays.

Build a spacesuit

Spacesuits do not come in a single piece, but are built from several pieces that are fastened together: the upper torso, the arms and the lower torso assemble.

Toilet break

While in the middle of a spacewalk you can't just pop to the loo, so a spacesuit contains a 'maximum absorption garment' – a fancy name for a nappy!

Gloves

Space is so cold that the fingertips in an astronaut's gloves contain miniature heaters. The gloves are made to be dexterous while providing a strong grip.

Dexterity

Spacesuits have to provide astronauts with a range of motion for when they are working outside of the space station.

Footwear

The boots on current spacesuits are soft and not really made for walking, just floating. New boots will have to be designed for going back to the Moon or Mars.

Life support system

The life support system contains oxygen tanks as well as a battery for power, water-cooling equipment and a fan for essential air circulation.

Ventilation garment

The Liquid Cooling and Ventilation Garment is made from skin-tight Spandex and worn beneath the space suit. It contains over 90 metres' worth of tubing to remove and recycle body heat, carbon dioxide and perspiration.

How do jetboards drive on water?

Is this the future of surfing? Adrenaline junkies rejoice, the jet-powered surfboard is making waves

Is there anything more annoying than grabbing your board and wetsuit on a beautiful day and heading to the coast, just to arrive and see a flat, calm ocean? Instead of cursing yourself for not checking the surf report, check out the motorised variety of surfing craft.

The WaveJet is a modular 'pod' designed to fit onto almost any surfboard, kayak or stand-up paddle board. It's battery-powered, rechargeable and operated by an accompanying watch unit. Allowing surfers to travel at around three-times faster than paddling, the WaveJet technology works much like the way a jet ski does, just downsized. Twin motors power two miniature water jets that suck in water and then expel it, creating enough thrust to get the rider into the line-up and ready to ride.

A similar competitor is the JetSurf, which is an entire board unit (instead of WaveJet's pod concept) that is designed to be much faster, reaching speeds of up to 58 kilometres per hour. Made of carbon fibre, the JetSurf boards are very light and portable, with bindings to keep the rider's feet on the board. Initially designed for racing on flat water, the JetBoards can also hold their own in the big ocean swell. The 'hull' is hydrodynamically designed and looks almost like a small speedboat instead of a surfboard.

All of this is powered by a small combustion engine with a unique exhaust system that is the key to producing such high speeds that most (sensible) riders have taken to wearing motocross helmets while on the water.

The JetSurf board

The board that gives your surfing skills an extra boost, with no paddling required

History of motorised surfboards

The idea has been floating around since the 1930s, when a few individuals tinkered with putting motors on surfboards. There are even a few examples of them being used by lifeguards. But it wasn't until the 1960s that the tech took a step forward. While a few manufacturers put outboard motors on surfboards, the first jetboard wasn't produced until 1965. Designed by aircraft engineers, it was created to get the surfer through the waves to save energy on paddling.

The 1980s saw the invention of the PowerSki JetBoard, where the jet technology was perfected so that the board was faster and more manoeuvrable. A range of boards were developed that could function more like a jet ski – designed for use both on flat water and to catch waves. They were also made from lighter and more manageable materials.

What's inside Boeing's 377 Stratocruiser?

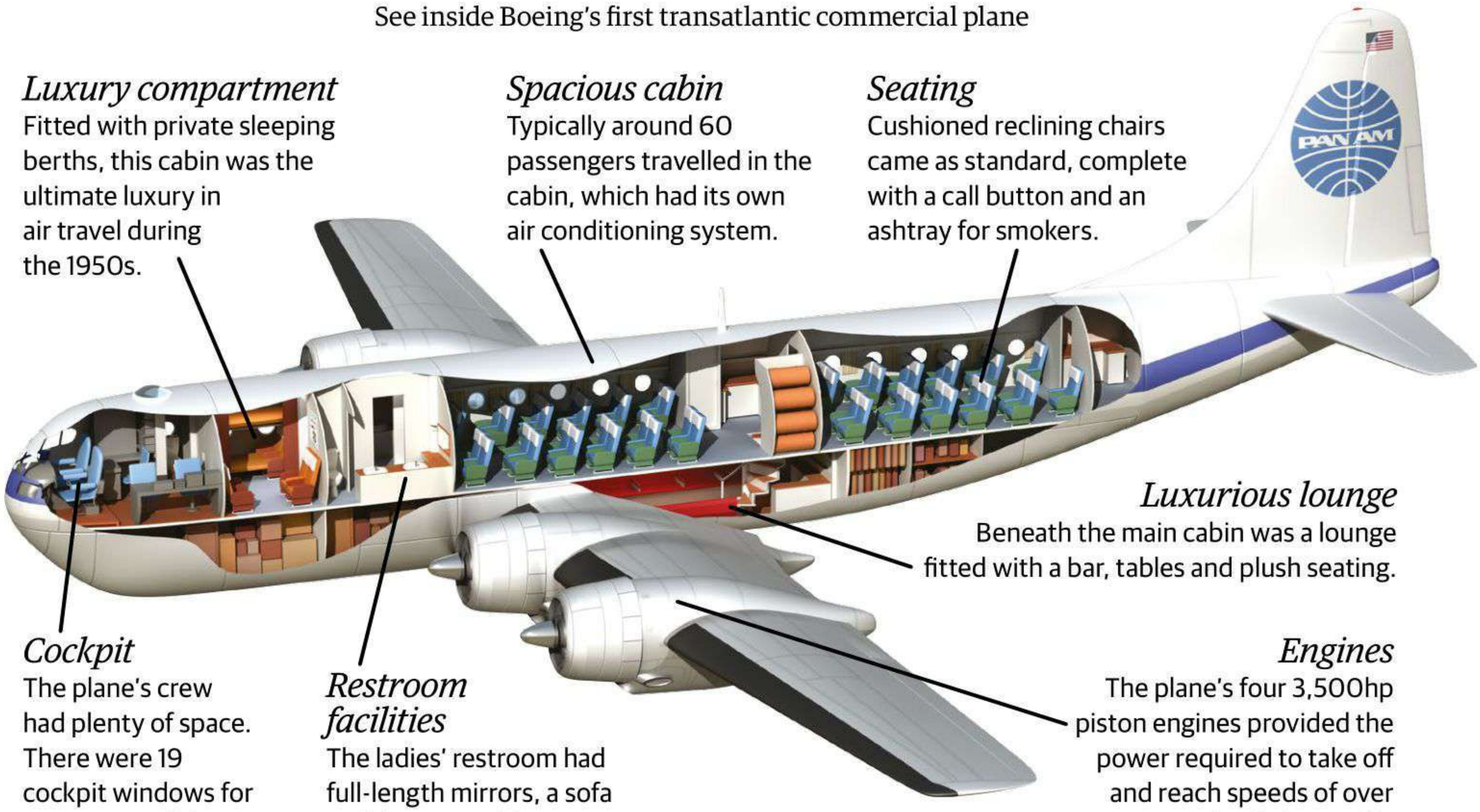
The Fifties saw aircraft reach new heights in luxury

Following World War II, cutting-edge military technology was put to commercial use. In the late 1940s, Boeing unveiled the 377 Stratocruiser, an airliner based on the B-29 Superfortress Bomber. The wings had retractable flaps to help minimise drag and allow higher speed, which kept flights as economical as possible.

Four 3,500-horsepower piston engines drove the 377's propellers, helping it reach an altitude of 9,750 metres (32,000 feet). The 377's engines were quite unreliable, due to their complex, 28-cylinder composition. Although designed to fly with only three working engines, this did not save the plane from catastrophe. Between 1951 and 1970, Stratocruisers suffered 13 hull-loss accidents. This is one of the reasons the 377 was retired commercially in favour of jet aircraft.

Post-war air travel

See inside Boeing's first transatlantic commercial plane



Luxury compartment
Fitted with private sleeping berths, this cabin was the ultimate luxury in air travel during the 1950s.

Spacious cabin
Typically around 60 passengers travelled in the cabin, which had its own air conditioning system.

Seating
Cushioned reclining chairs came as standard, complete with a call button and an ashtray for smokers.

Luxurious lounge
Beneath the main cabin was a lounge fitted with a bar, tables and plush seating.

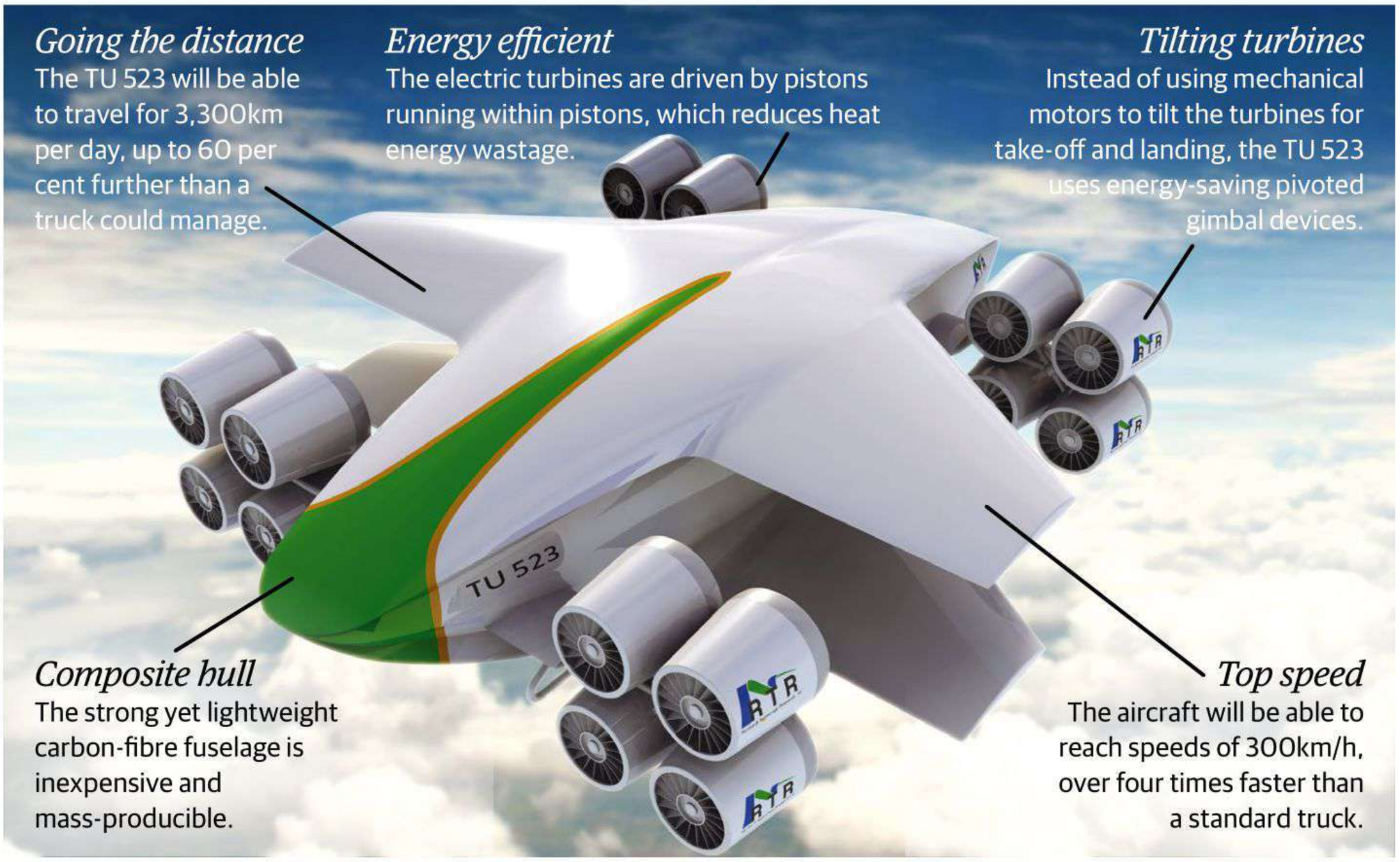
Cockpit
The plane's crew had plenty of space. There were 19 cockpit windows for optimum visibility.

Restroom facilities
The ladies' restroom had full-length mirrors, a sofa and dressing tables.

Engines
The plane's four 3,500hp piston engines provided the power required to take off and reach speeds of over 600km/h (373mph).

What is the future of VTOL aircraft?

Meet the fleet of aircraft that could revolutionise heavy cargo transportation



British company Reinhardt Technology Research (RTR) have designed the TU 523, a vertical take-off and landing (VTOL) aircraft, capable of transporting heavy shipping containers without the need for expensive new infrastructure. The craft uses a hybrid electric generator to supply power to a series of electric turbines on demand, which can tilt horizontally and enable vertical take-off and landing.

Once in the air, the turbines automatically tilt back again, while the wings generate lift just like on an airplane. RTR has already built a 1:4 scaled model of the TU 523, which will be sent on a 60-day journey from the UK to South Africa. A full-scale version is then to be developed, which can be mass-produced at a capacity of 30 units per month and cost no more than £400,000 ($580,000) each.

What is the world's largest ship?

Discover how this gigantic, record-breaking vessel rules the waves

The largest, most monstrous, hands-down winner in the big ships size class is Maersk's Triple E design. Offering 16 per cent more container space due to its wider, bulbous bow.

The engine is also positioned further back to aid stability and allows for yet more containers to be squeezed in above and below deck. The propellers are larger, and move slower to conserve fuel and reduce emissions. The hull is designed to be completely recyclable, while the ship's waste heat recovery system captures the heat and pressure from the exhaust and uses it to move turbines.

The vessel is so enormous it has to be built in a way that can withstand the force of waves, made from flexible materials that can bend with the movement of the ocean. It's possible to see the walls flexing and distorting as the craft moves in heavy swell.

Below
The first Triple E was delivered in July 2013, and was named the Maersk Mc-Kinney Moller

How do train drivers know when to stop?

Drivers are still essential to making sure trains run safely

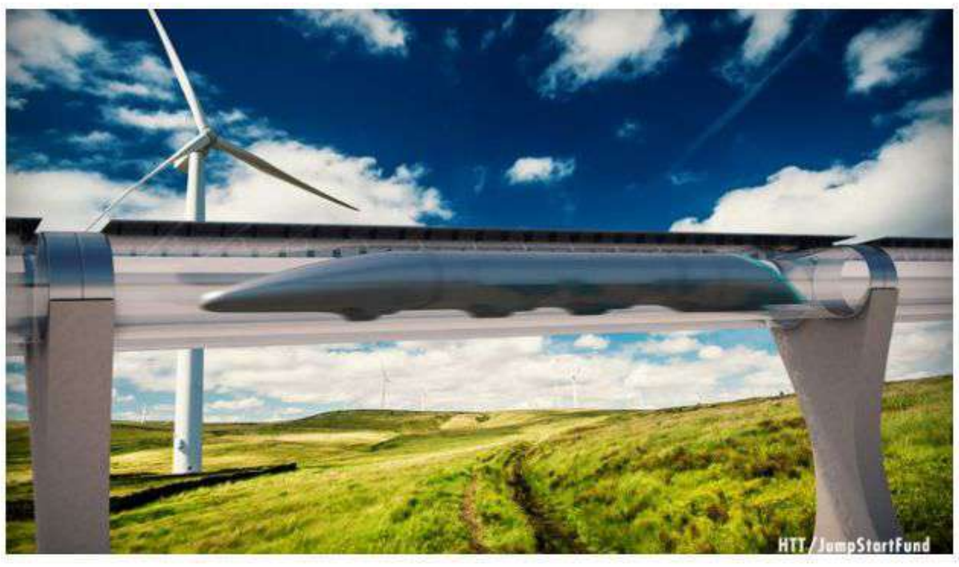
Above
Despite new technology, most train drivers still need to know when to start stopping

Speeding trains can take miles to come to a stop so they have to start slowing down long before they get to a station. Some high-tech trains tell their drivers when to start slowing, but generally drivers are trained to understand the routes they travel on and will know when to start braking themselves. As the train slowly pulls into the station, signs and marks tell the driver exactly where to bring it to a complete halt. When the train is travelling between stops, trackside signals, similar to traffic lights, will order drivers to stop if there are problems on the line ahead.

Can we move faster than sound?

Travel at almost the speed of sound for the price of a bus ticket on the Hyperloop

The Hyperloop is a futuristic mode of transport that will almost reach Mach 1 speeds. Transportation pods will travel through a sealed tube powered by electromagnets, inside the atmosphere will be extremely thin, to a near vacuum. Only five per cent of the track will be used for propulsion and the pod will simply glide for the remainder. Two companies, Hyperloop One and Hyperloop Transportation Technologies, have emerged as the frontrunners for the first prototype, and are developing systems to be in place in the US, India and the UAE. Estimated for completion in 2030, the Hyperloop is planned to be an inexpensive mode of transport that will have minimal impact on the environment.



Below
Hyperloop vacuum tubes could be raised on pylons, so they can go over roads

What would happen if a plane window was opened in mid-air?

The windows on passenger planes are sealed for a reason

The atmosphere in an airplane is at a higher pressure than the atmosphere the plane is flying through. If you could open a window, the cabin would decompress. This is because air pressure always tries to balance, so high-pressure air will flow towards lower-pressure areas. Loose objects would be sucked out the window, and it would quickly become hard to breathe. That's why plane windows don't open!

Right
Opening a plane window in flight would be very dangerous

What are airless tyres?

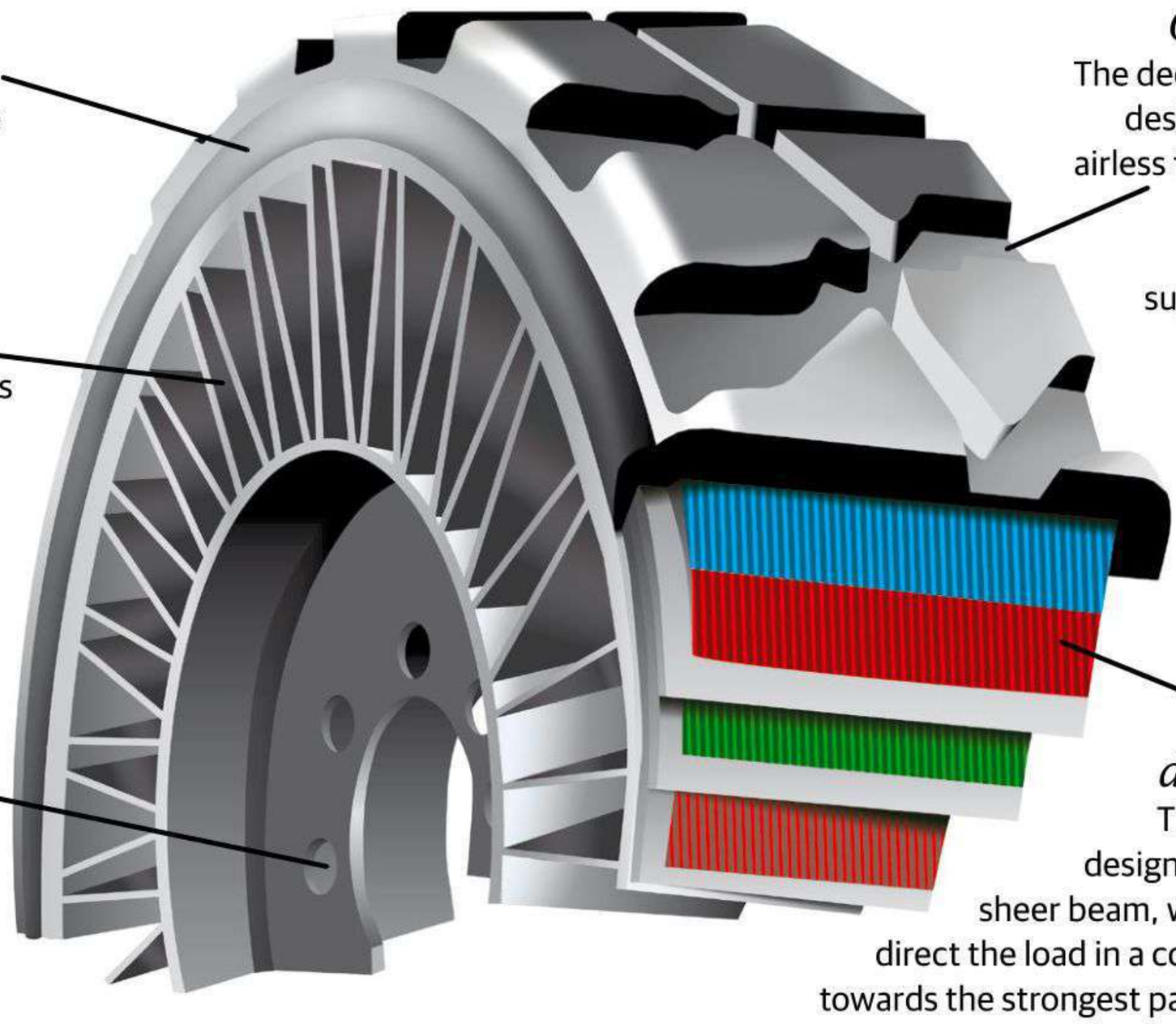
Will Michelin's new design end the fight against flat tyres?

Michelin's airless tyre design promises to put an end to frustrating slow punctures and dangerous high-speed blow-outs. Their new 'Tweel' is a combined wheel and tyre assembly in a single, tough unit, primarily designed for commercial use in landscaping, agriculture and construction. If successful, the designers hope to implement the technology in other vehicles.

Solid, air-free tyres have actually existed for quite a while but as they are incredibly hard, the vehicle bounces when travelling over rough terrain. The Michelin Tweel combats this by compressing when it is being driven on rugged roads. Another advantage is that it's much more eco-friendly than current air-filled pneumatic tyres, as it is made of a plastic resin that can be repeatedly recycled. This means that these tyres will have very little environmental impact even when they are replaced.

Inside an airless tyre

See the features that make the Tweel so durable



Undertread
A thick undertread means the core of the tyre can be retreaded multiple times.

Strong spokes
The tyre's polyresin spokes help make the ride more comfortable by reducing the amount of bounce when driving.

Great compatibility
Each tyre is fitted with eight-hole steel hub bolts, allowing them to fit all standard skid-steer machines.

Open tread
The deep open tread design makes the airless tyre very easy to clean, and also provides superb traction.

Zero-degree belts
These belts are designed to create a sheer beam, which helps to direct the load in a consistent path towards the strongest part of the tyre.

How do road sweepers work?

Meet the machines that keep our streets clean

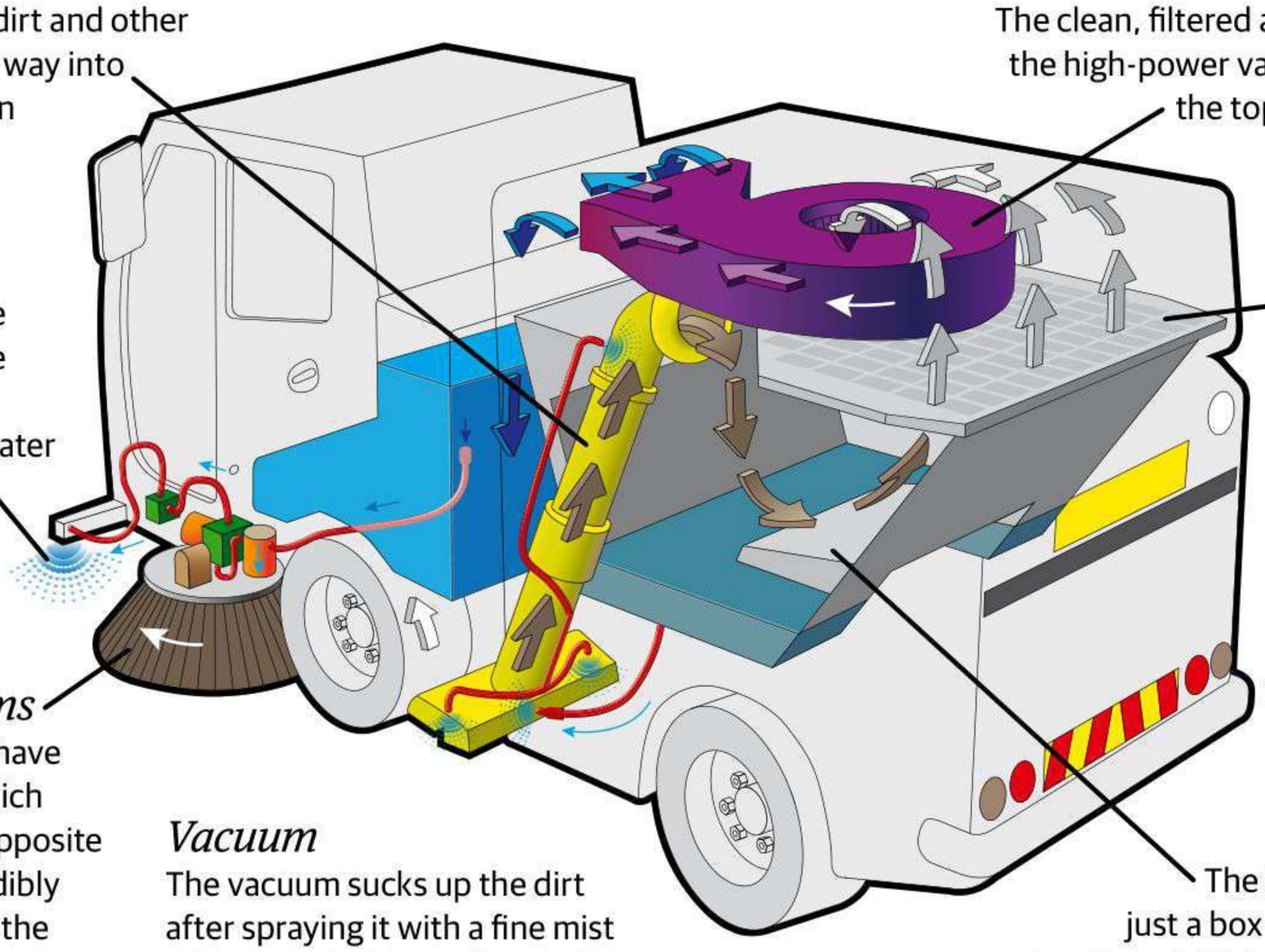
Mechanised road sweepers are like huge vacuum cleaners that suck up everything from leaves and dirt to paper and cans, leaving the roads behind them squeaky clean.

High-pressure water jets break up any caked-in dirt. Rotating 'gutter brooms' sweep this dirt, and any other litter, from the edges of the road into the middle. The sweeper then sprays out a fine mist of water, helping to hold the dust down. The vacuum system is connected to a hose that sits under the centre of the sweeper, it sucks up litter from the road into the vehicle's collection bin.

Once it's in there, the litter is shaken and dried, to break it up into smaller particles, and passed through filters. The dirt is trapped, while the cleaned air is either recycled back into the vacuum system, or released into the environment.

Sweep me off my street

Lots of different technologies are used to keep a city's roads clean



Hose
The dampened dirt and other litter make their way into the collection bin via this hose.

Water jets
Dried dirt can be tough to remove from roads, so high-pressure water jets are used to break it up.

Gutter brooms
Most sweepers have two brooms, which spin around in opposite directions incredibly quickly to move the dirt into the centre.

Vacuum
The vacuum sucks up the dirt after spraying it with a fine mist of water to help it stick together.

Recycle
The clean, filtered air is recycled by the high-power vacuum system at the top of the vehicle.

Filter
Even the smallest dirt particles get caught in these filters, which are replaced regularly, just as you would need to in a normal vacuum.

Bin
The bin is more than just a box – it can shake to break up dirt into smaller pieces.

How do race suits keep drivers safe?

Find out about these hi-tech overalls

When your job involves speeding around racetracks at over 200 kilometres per hour, safety is paramount. Drivers' clothing must be flame retardant to help shield them in the event of a fire. Materials are subjected to stringent open flame tests in laboratories.

An artificial fabric called Nomex is widely used as it has excellent fire-resistant properties and is very lightweight. Modern drivers' suits are typically made from two to four layers of Nomex, and are thoroughly tested before use to ensure they can withstand temperatures of 600–800 degrees Celsius. To be suitable for use, the inside of the suit must not exceed 41 degrees Celsius for at least 11 seconds when exposed to such heat. Zips must also be able to withstand high temperatures so they do not melt or burn the driver's skin. Even the threads that stitch the suit together have to be fire resistant. Another important feature is breathability; drivers can lose several kilos of sweat during a race, so it's important that this moisture can escape.

Drivers' suits are also specially designed to make sure that their senses aren't too restricted, which could interfere with their ability to drive.

© Prema Powerteam

How do aerodynamics work?

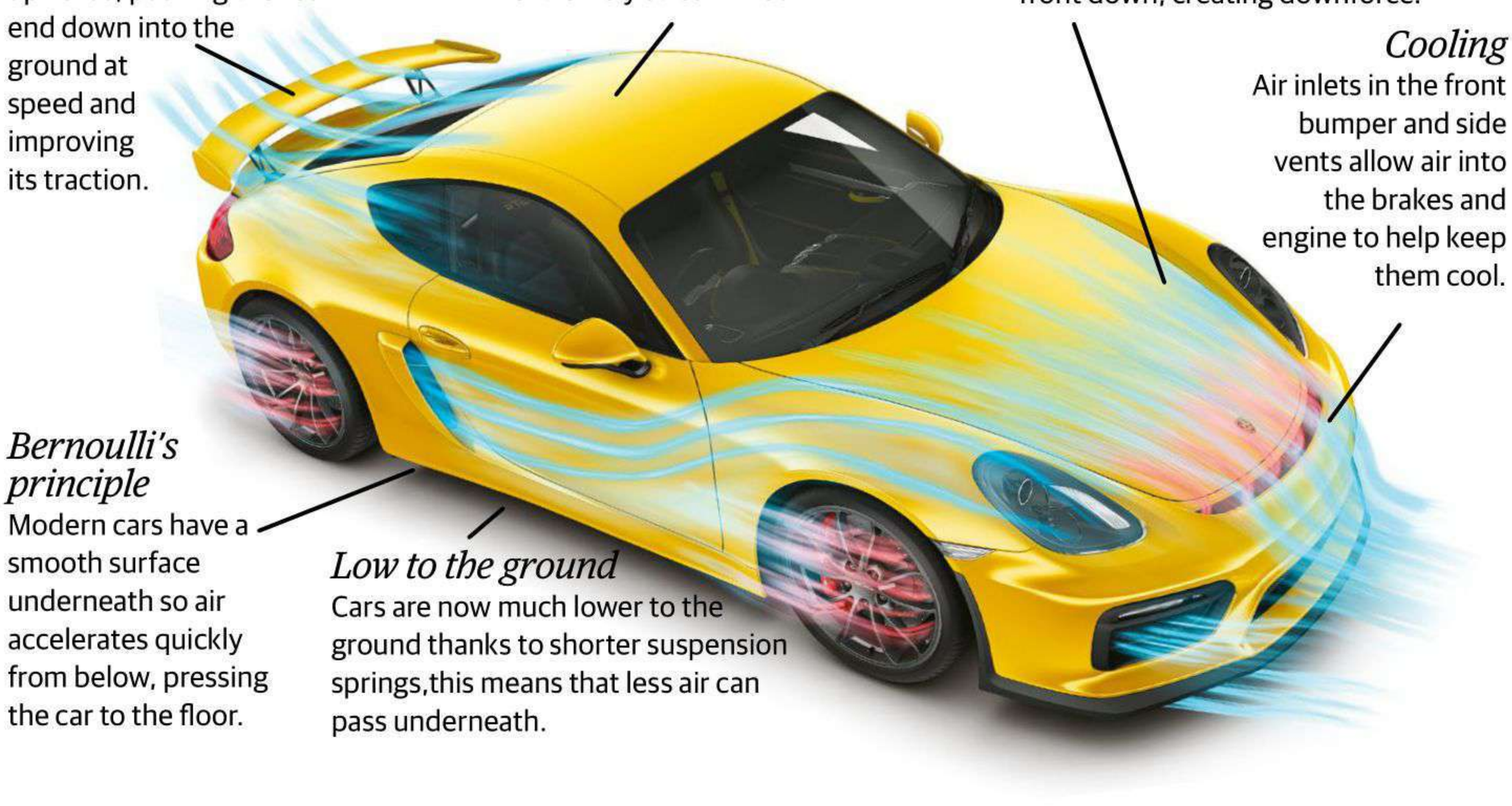
How the shape of a vehicle can help it slip through the air

As a car moves through the air it pushes aside air molecules, which creates a resistant force called drag. The faster a car travels, the greater the drag, meaning the car's engine has to work even harder to maintain speed. As car speeds have increased, it has become more important for drag to be kept to a minimum – that's where aerodynamics come into play. Ensuring a car has good aerodynamics means giving it a more chiselled appearance from the front, reducing its surface area that will come into contact with the air.

Enhancing the flow of air around a car not only reduces drag, making it more economical, but also allows it to slip through the atmosphere quicker, making it faster. Airflow is also utilised to keep key parts of the car cool, such as the engine and brakes, to maintain its performance even under sustained heavy use.

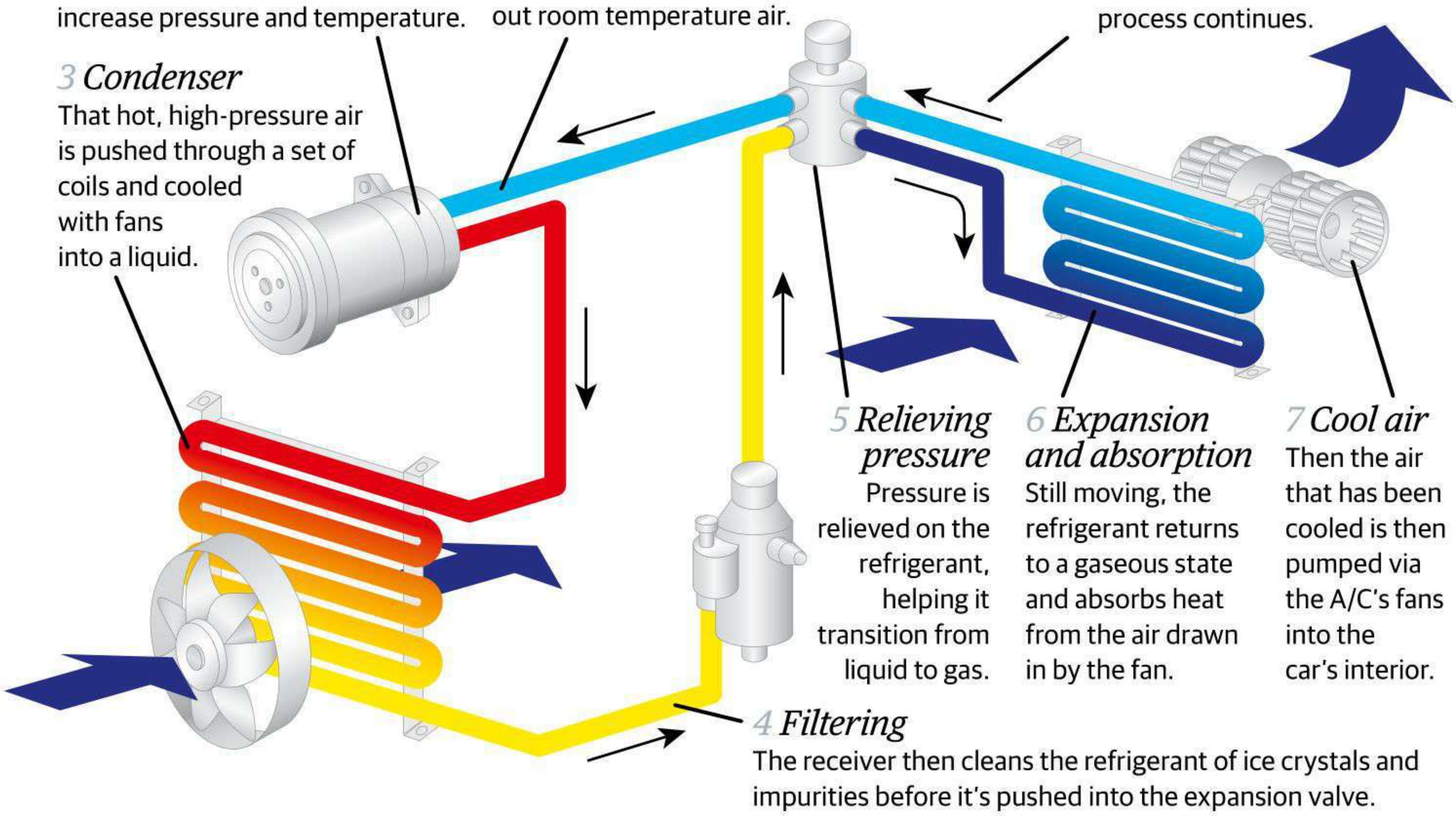
Using airflow to go faster

How a sports car is designed for improved performance



Riding in comfort

A crash course in how air con works



What is inside your car's air con?

The subtle engineering that keeps you cool behind the wheel

It all starts when you press the A/C button on your dashboard. Firstly, a refrigerant gas (usually Puron or Freon) is pumped through a series of tubes by a compressor. The compressor forces the vapour into a high-pressure state, causing its temperature to rise.

This hot air passes through a condenser, which uses fans to cool the refrigerant gas into a liquid. The cool liquid is then pumped into a receiver, which removes any moisture or ice crystals that could damage the circuit. Finally, it is pumped into an expansion valve that reduces its overall pressure, allowing it to pass into the evaporator.

The refrigerant has a very low boiling point and so becomes a gas again, even at the temperature of the car cabin. Heat from the air drawn in by the fans on the dashboard is then absorbed by the refrigerant, and the cool air that remains is pumped into the car's interior.

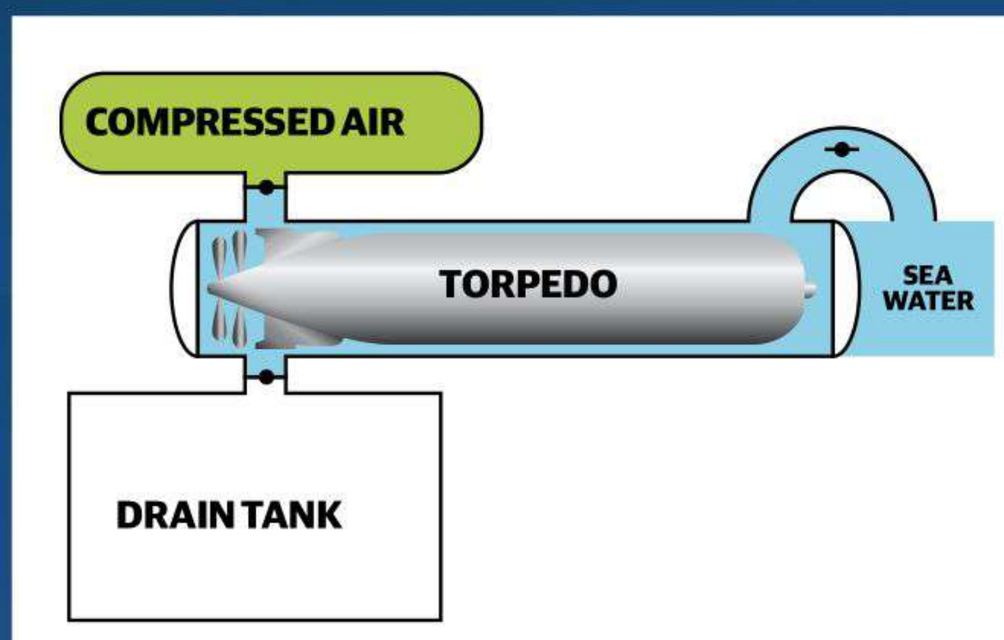
How are torpedoes fired?

Learn how to unleash the ultimate underwater weapon

Above
Torpedoes are fired from ships and submarines through their torpedo tubes

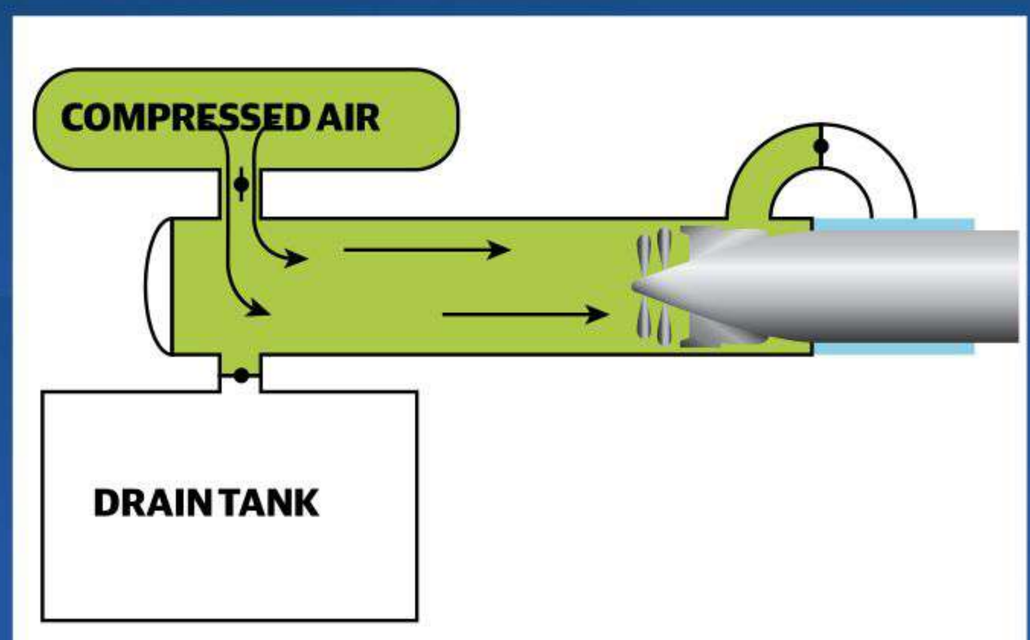
Load, aim and fire!

How to fire a torpedo during battle



1 Load your weapon

Load the torpedo through the breech door at the back of the torpedo tube and then close it. Open the valve to flood the tube with seawater from outside the ship, equalising the pressure inside and outside the tube.

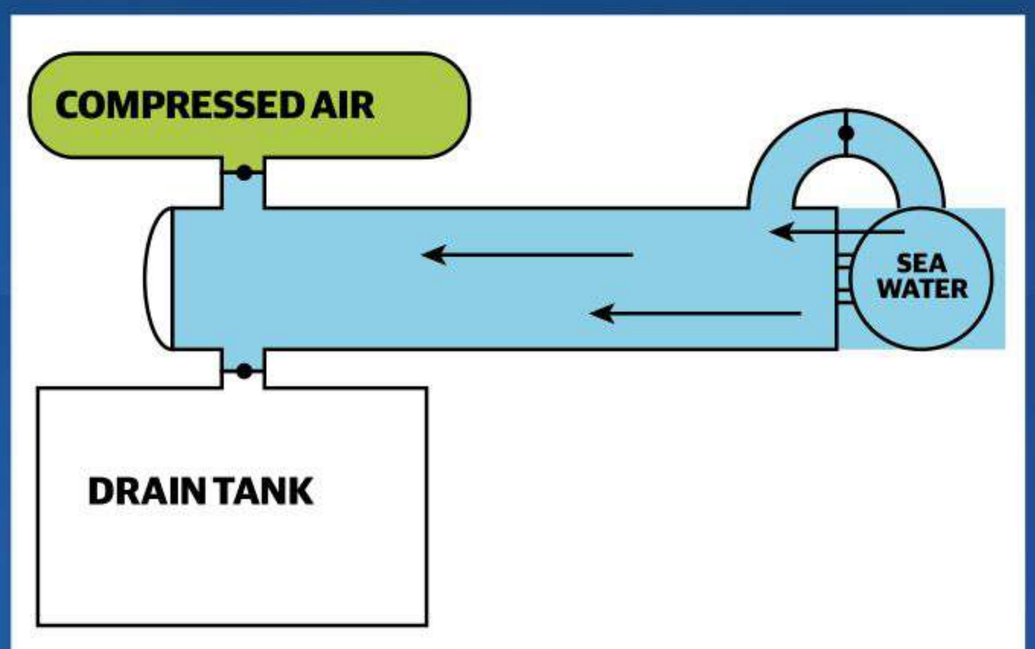


2 Fire!

Open the muzzle door at the front of the torpedo tube, open the compressed air valve to eject the torpedo. The air is vented into the ship, so that a bubble cannot escape to the surface and give away the ship's position.

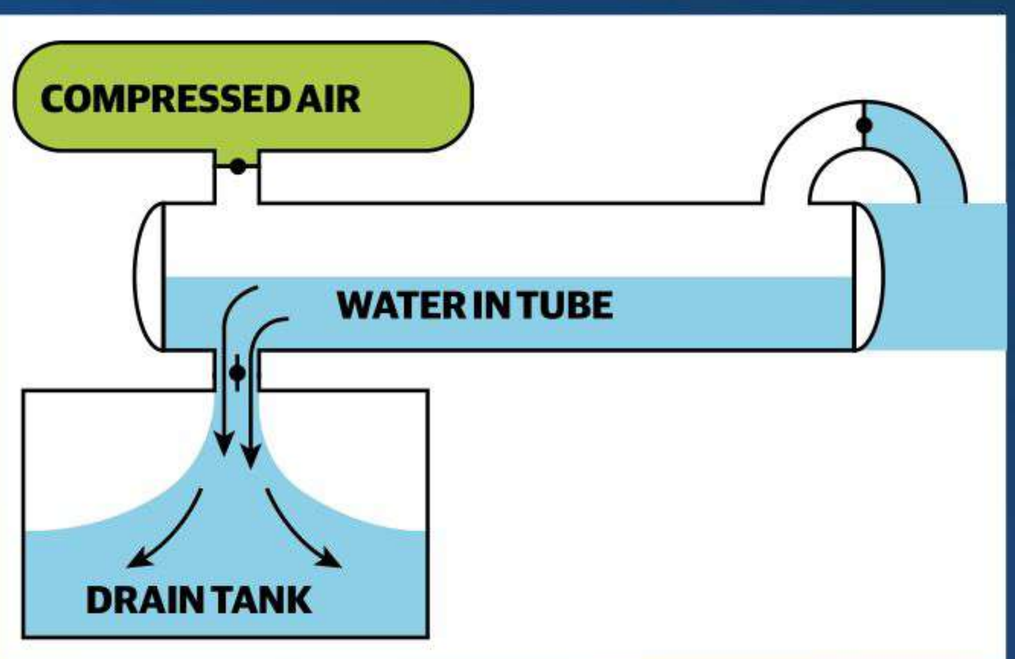
Torpedoes can be launched from both ships and submarines, using torpedo tubes lined up along the hull. World War II-era torpedoes were guided towards the target using an internal gyroscope, and their path could be fine-tuned using the rudders. A pendulum inside the torpedo kept it level. Many modern torpedoes are wire guided, so they can be controlled remotely after launch, before the wire is cut off and the internal guidance system takes over. Once the torpedo detects an enemy ship, or makes contact with it, the onboard explosive is detonated to rip a hole in its side and send it sinking without a trace.

Above
Torpedoes are fired from ships and submarines through torpedo tubes



3 Maintain balance

Shut off the compressed air valve and the torpedo tube will then fill with seawater through the open muzzle door. This will help to offset the lost weight of the torpedo to keep the ship balanced.



4 Reset and repeat

Shut the muzzle door and open the valve to the drain tank to empty the water from the torpedo tube. Once it is empty, you can then open the breech door and load another torpedo to start the process again.

How do we get real-time traffic data?

How modern sat navs keep you up to date with the latest traffic news

When sat navs first came onto the market they functioned only to get you from one place to another. Modern varieties now offer live traffic data, to keep you aware of developments on the roads as they happen in real time.

The bulk of this information is actually provided by the drivers' journeys as they're undertaken. A small mobile device, similar to a SIM card, is built into the sat nav, which sends data on the speed it's travelling at and its precise geographical location back to the manufacturer's headquarters.

Along with this data, live information is gathered from mobile phone networks, radio reports and government organisations, which have access to traffic data through a multitude of cameras and road sensors. These detect the volume and speed of vehicles, using either radar or active infrared, and then wirelessly transmit the results to a server. By combining these various data sources, it's possible to show where the most congestion is and where traffic is still flowing freely.

Live traffic data can also be used to create faster, alternative routes for drivers who are already part way through their journey. Once these have been compiled they are sent directly to sat nav systems; drivers can then choose to change their route to save some time or continue on their original path.

Below
Live traffic data can be used to offer alternative routes to delayed drivers

What is countersteering?

When steering in the opposite direction helps turn corners

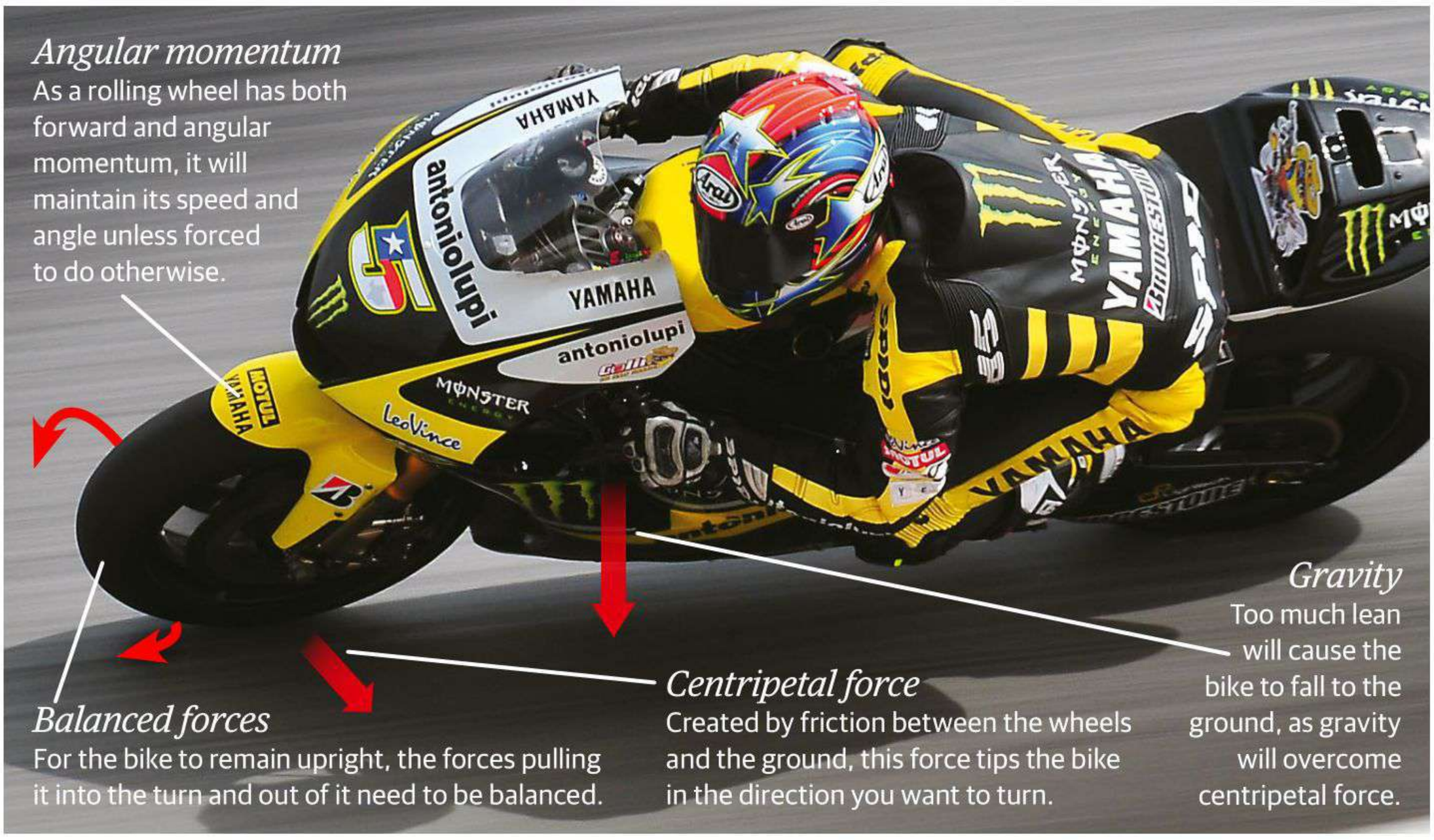
When taking a corner, a motorcyclist will momentarily steer in the opposite direction to where they want to go. This is known as countersteering, and is a safer way of turning at high speeds.

To turn left, you start by pushing gently on the left-hand grip, which turns the front wheel to the right. This positions the wheels for a right-hand turn but as you are going from a straight direction of travel, this turn is unstable. The friction created between the wheels and the ground causes the bike to tilt the other way. This leans you and the bike to the left, setting it up for a left turn instead.

Once you've released the pressure on the left-hand grip, the bike will perform a safe, stable, left-hand turn. The amount you lean is very important – taking a turn incorrectly can lead to severe injury.

Mastering the turn

How do riders balance out forces to keep their bike from falling?



How does the Super Yacht Sub work?

Explore life beneath the waves in this luxury submarine

The Super Yacht Sub 3 (SYS3) is a personal submersible, costing a bank-breaking £1.6 million ($2.4 million), that gives three passengers the opportunity to explore 300 metres below the ocean's surface.

Four electric thrusters propel the SYS3. Two mounted at the rear of the sub, while the other two are on the side, allowing movement in any direction. The power comes from a lithium-ion battery, which provides 21.6 kilowatt-hours to the thrusters and onboard operating systems. Enabling the sub to reach a top speed of 2.8 knots (just over five kilometres per hour), both underwater and on the surface.

The submarine is steered using a dual-joystick controller featuring a 'dead man's switch', which must be pressed every ten minutes to prevent the sub from returning to the surface.

Exploring the oceans

See the features that help the submarine to function underwater

Safety
The safety buoy is automatically released when the sub dives, marking its position to anyone who is at the surface.

Single lifting point
The sub can be lifted from the top using only one cable, making it easy to retrieve from the water and return to the yacht's garage.

Thrusters
Four thrusters allow the sub to move in all directions while it is underwater.

Underwater visibility
The sub's viewing window is made from acrylic, which withstands 3,600 tons of pressure when the vehicle dives to 300 metres.

Power
The lithium-ion battery provides 21.6 kilowatt-hours of power, allowing the sub to dive for up to six hours on a single charge.

Controls
Operated mainly by the handheld controller, all other controls are kept away from the front to leave the underwater view unobstructed.

Why are BMX bikes so small?

The reasons behind the bikes' compact frames

The tiny proportions of BMX bikes make them lighter and more manoeuvrable when it comes to sprinting, doing stunts and negotiating jumps. BMX cycling involves a combination of racing and jumping, so riders need a bike that is lightweight and agile but also tough enough to withstand landing repeatedly from jumps. The small size of the bikes also allows BMX riders to swing the bike around 360 degrees or perform backflips, with the low seat position providing extra clearance. Finally, the rider's hunched position over a BMX's small frame allows them to absorb shocks and rapidly shift their bodyweight and centre of gravity to perfect their amazing, gravity-defying stunts.

Above
BMX cycling started in the 1970s, and became an Olympic sport in 2008

Can aviation be eco-friendly?

The future of aviation is designed to be lightweight, cleaner and quieter

When it comes to reinvention of light passenger aircraft, there are few more innovative than the Bio-Electric-Hybrid-Aircraft (BEHA).

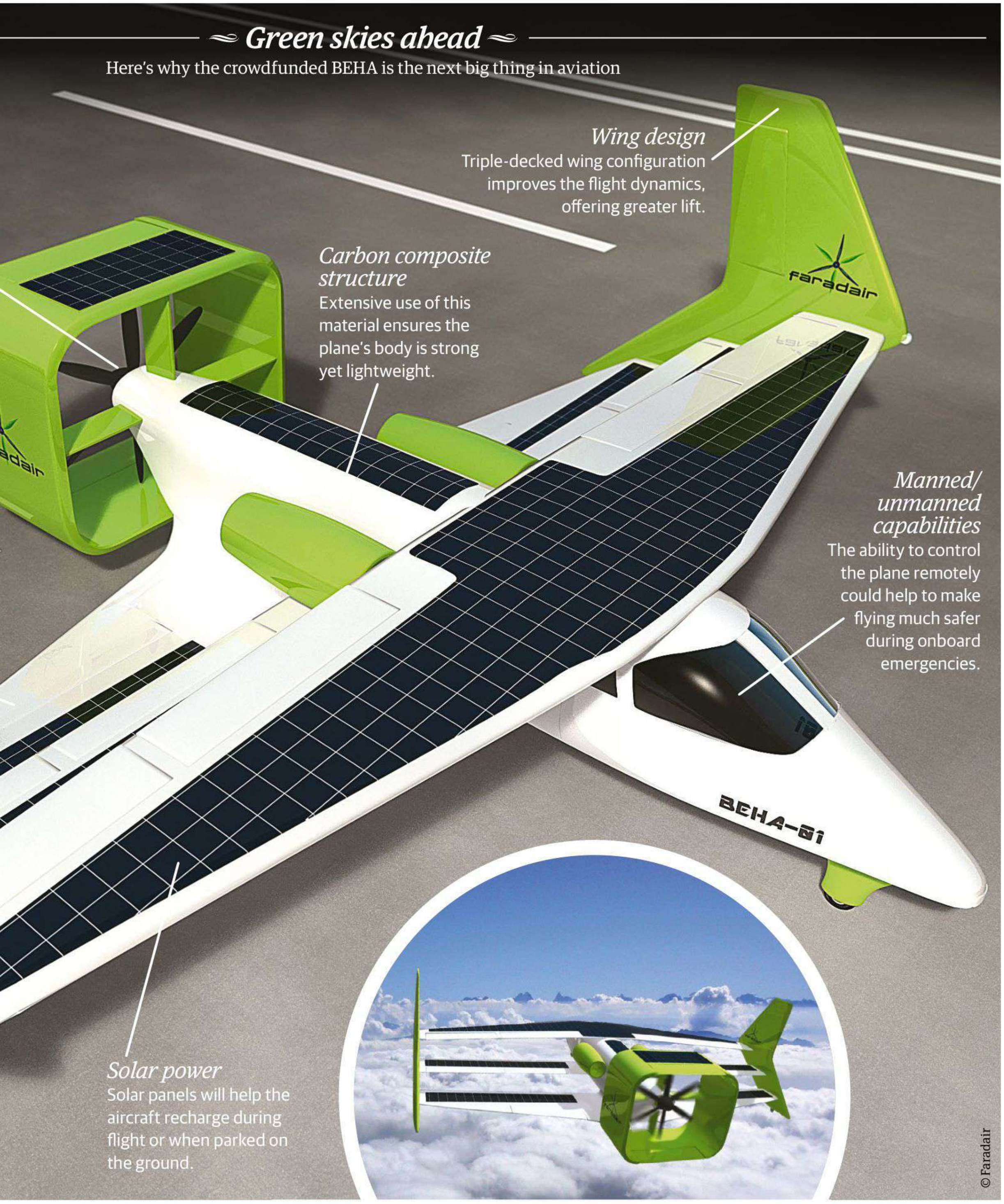
Seeking to lower costs while offering safer operational capability with lower noise and emissions the BEHA has three engines on board, with one bio-diesel engine effectively powering two electric motors – though the plane can be flown purely on the bio-diesel reserve engine. This improves its safety in the event of engine failure. Solar skin panels will ensure greater energy generation and recovery during flight, in a bid to reduce emissions.

What's more, the plane can take off and land on pure electric energy for reduced flight noise, ensuring it can be used around the clock, even in urban areas where night restrictions may apply. It's not just the plane's power source that breaks with tradition, either. Made entirely from carbon fibre BEHA is designed to be lightweight yet strong.

Lift-off won't be for a while yet, as the prototype is still in development, but the sky's the limit according to Faradair.

Green skies ahead

Here's why the crowdfunded BEHA is the next big thing in aviation

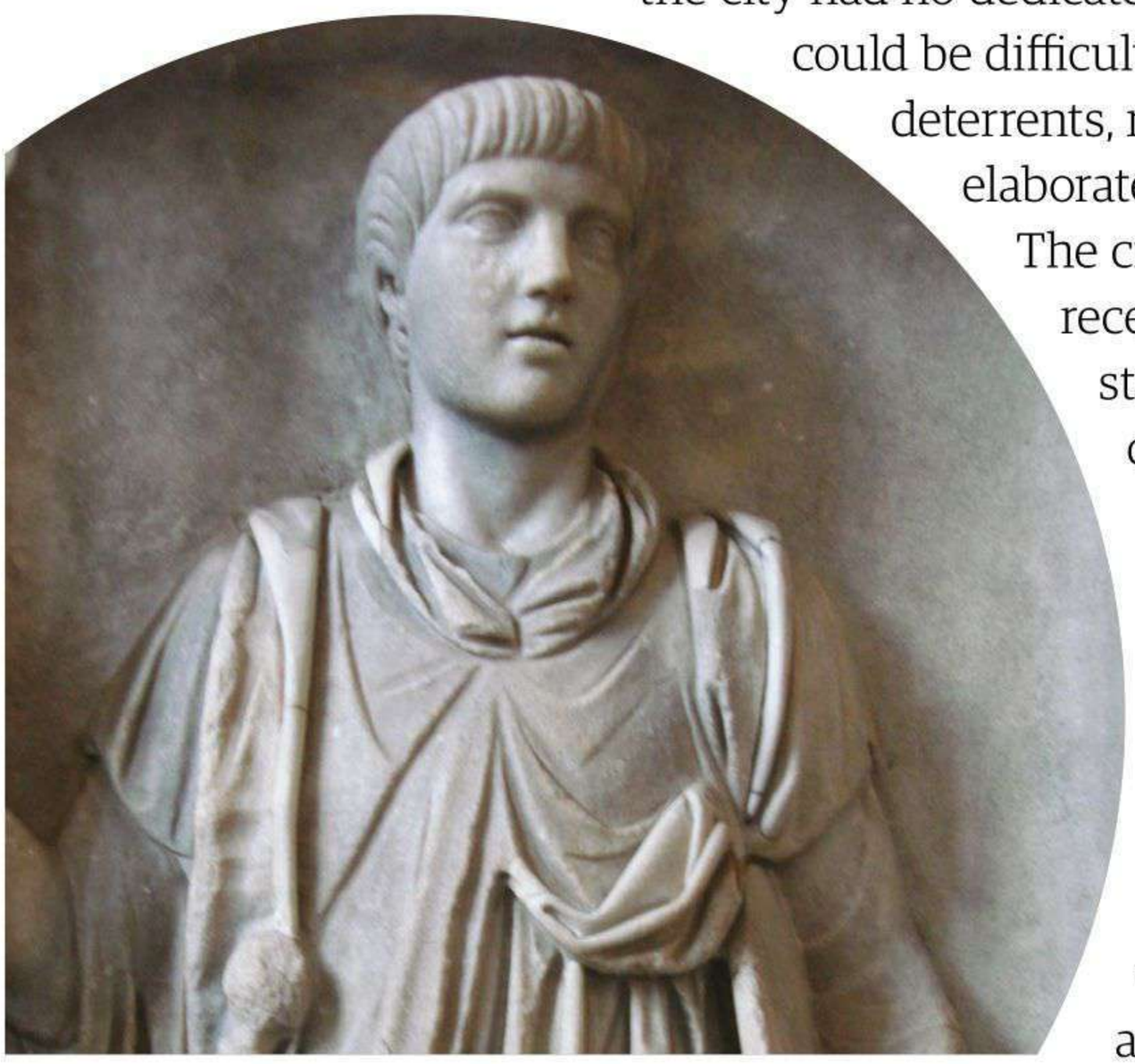


© Faradair

How did the Romans deal with crime and punishment?

Hold on to your coin purse and take a trip down the mean streets of ancient Rome

During the first century CE it is estimated that the city of Rome supported 1 million inhabitants. As with any city, densely populated areas with wide class divides can easily become criminal hotspots. The foundation of Roman law was known as the Twelve Tables, a dozen rules that every citizen had to obey. The Twelve Tables were so important that schoolchildren learnt to read and write by copying laws down and reciting them. While some soldiers, volunteers and officials were tasked with keeping the peace, the city had no dedicated police force, so upholding the law could be difficult. Harsh punishments were the main deterrents, ranging from a brutal beheading to elaborate public executions at the Colosseum. The crimes committed and punishments received often depended on the social standing of the accused. High-class citizens convicted of major crimes were often given the option of exile rather than execution. Slaves, on the other hand, were punished harshly. If one slave was caught committing a crime, it was not uncommon for all the other slaves of the household to actually be punished as well, this was in order to try and discourage any possible uprisings.



Below
The Praetorian Guard was very influential and played a role in the removal and accession of several different emperors

Keeping the peace

While there was no official police force in Ancient Rome, leaders enlisted some groups to be in charge of crime prevention. Vigiles were volunteers who performed the dual role of police and firefighters. They patrolled the city at night, scouting for potential criminals or runaway slaves, while also helping to extinguish fires. Urban cohorts were soldiers that played the role of riot police. Rather than patrolling the streets, only summoned if a situation got out of hand.

The Praetorian Guard was responsible for protecting the Emperor, just like bodyguards. Despite only having a single person to protect, at times the Praetorian Guard actually consisted of over 1,000 men. None of these groups were tasked with catching criminals after a crime was committed. If Roman citizens were victims of crime, it was actually their responsibility to catch the perpetrator and then take him or her to the magistrate for a trial.

Traitors

Treachery among the upper classes was a serious offence. Anyone convicted of betraying Rome or the Emperor was banished or killed.

Deserters

Military discipline was severe. Soldiers guilty of desertion could be beaten to death by other members of their unit.

Adulterers

Adultery laws made affairs illegal for married women. An adulteress could be forced into exile or sentenced to death.

Thieves

For free citizens, punishments for stealing ranged from fines to flogging, but slaves could face death.

Assault

One of the Twelve Tables stated that anybody who broke another's limb should receive punishment in kind.

Counterfeiters

Producing fake coins and other instances of fraud were punishable by banishment or death.

What were the secrets to Tudor beauty?

The dos and don'ts of looking gorgeous in 16th century England

Below
Anne Boleyn wasn't considered beautiful, due to her dark hair and sallow skin

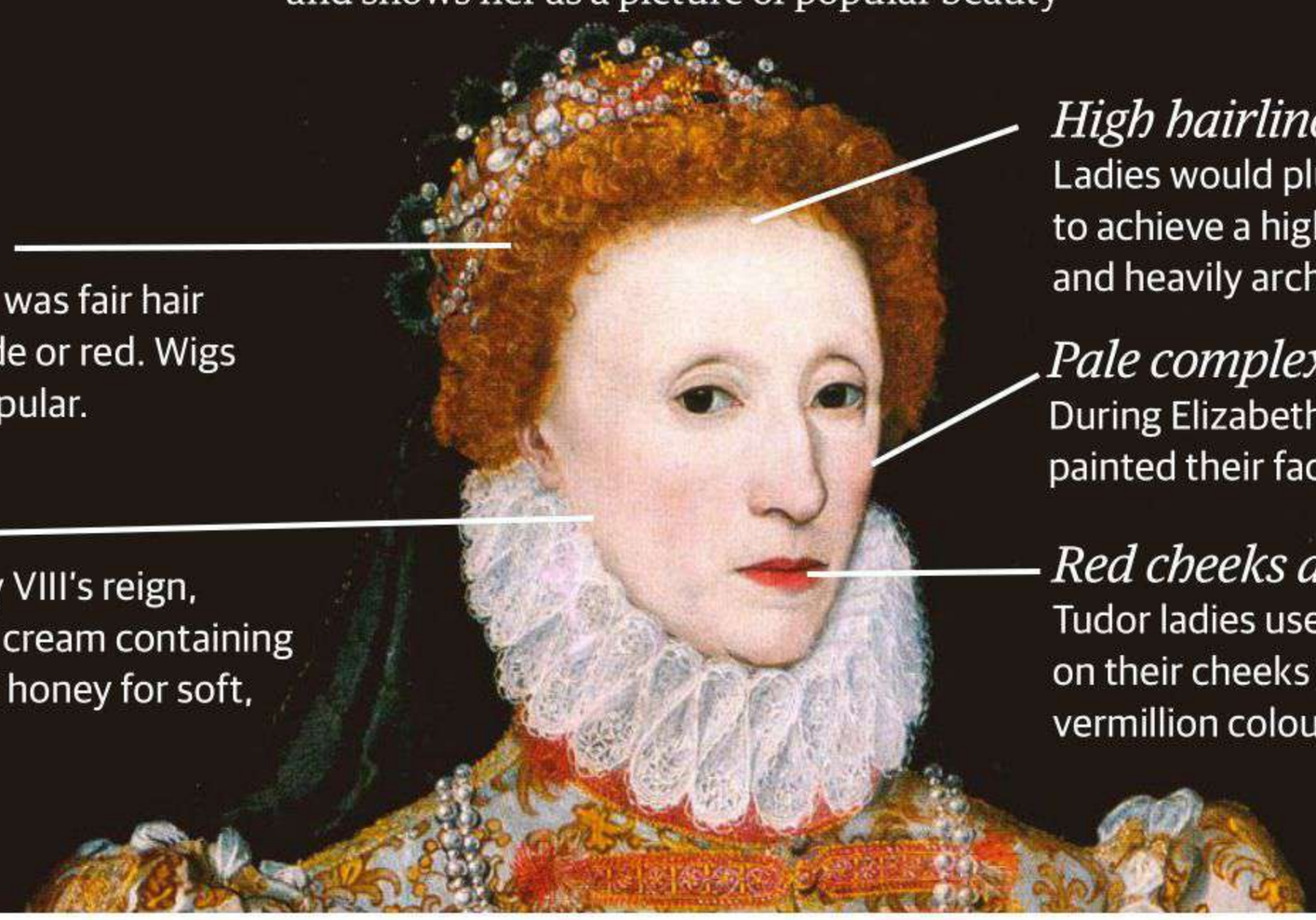
Perception of beauty varies greatly throughout history, and the Tudors went to great lengths to achieve the ideal.

Pale skin was a sign of wealth and relaxation, and tanned, or sunburned skin was an indication of hard labour. Women softened their skin with creams and ointments, and even used ceruse, a cream made of white lead and vinegar, to whiten their complexion. Many suffered from lead poisoning as a result, but they also went to further extremes, such as bleeding themselves to remove any rosy flush.

Darker-haired ladies dyed their locks red with henna, or tried to lighten it using urine or cumin, saffron seeds, celandine and oil. Wigs were also fashionable, and high-class women would wear these to achieve the desired colour without a messy dye job.

The model queen

The Darnley Portrait of Elizabeth I was completed circa 1575 and shows her as a picture of popular beauty



Light hair
A Tudor ideal was fair hair – either blonde or red. Wigs were very popular.

Soft skin
During Henry VIII's reign, women used cream containing beeswax and honey for soft, dewy skin.

High hairline
Ladies would pluck their hairline to achieve a higher forehead, and heavily arch their eyebrows.

Pale complexion
During Elizabeth I's reign women painted their faces with ceruse.

Red cheeks and lips
Tudor ladies used mercuric sulphide on their cheeks and lips for a bright vermillion colour and blush.

Who were Africa's witch doctors?

The truth behind the so-called spiritual healers

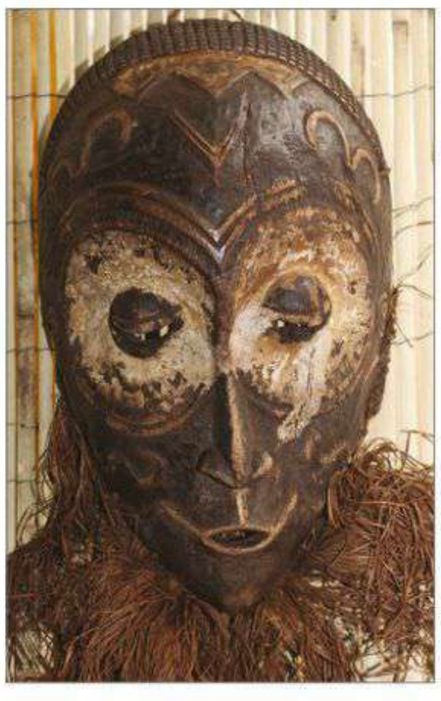
African witch doctors have been practising for around 5,000 years, and are neither witches nor doctors. Their roles and titles vary between regions and tribes but these folk healers often act as either a herbalist, a diviner, or both. They were and still are very highly respected members of society, whose aim is to cure the sick and keep evil spirits away with the help of various different potions and traditions.

However, scientists hope to learn more about the effectiveness of the traditional medicines used by these healers, as they have not been well-studied. Some believe it is possible that certain herbal remedies may be beneficial in the treatment of HIV symptoms.

Traditional dress

With vibrant headwear and facial piercings, witch doctors were both feared and respected

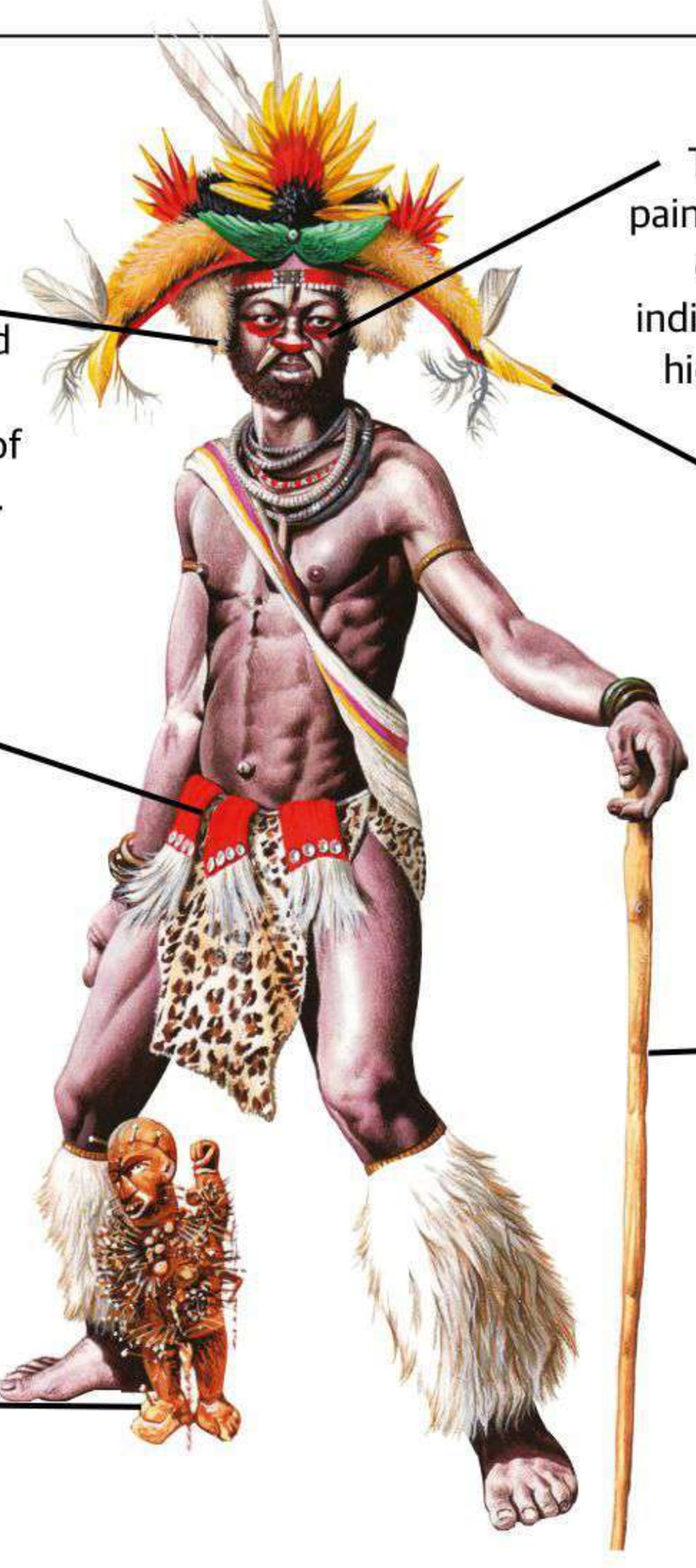
Below
Depending on the type of procedure they're performing, witch doctors will sometimes wear a mask



Facial piercing
Large facial piercings signified status, and were also traditional throughout most of the world's tribal civilisations.

Loincloth
Not just to keep their dignity, the loincloth was a key part of the witch doctor's traditional dress, often containing a medicine pouch.

Nkondi
These small wooden statues were used by the Kongo people. They were believed to house a spirit that could hunt down enemies.



Face paint
The witch doctor's face paint had hidden meaning; circles around the eyes indicated the ability to see hidden sickness and evil.

Headdress
Made from a range of feathers, teeth and even animal skins, the headdress was designed to impress and intimidate.

Staff
This simple tool was ideal for mixing herbal remedies or drawing in the dirt.

What was it like to be an American GI?

The Vietnam War saw huge changes in uniform regulations

A lightweight, wind-resistant material called poplin was used to keep soldiers cool in the blistering Sun. This fabric also featured a threaded grid design that prevented it from ripping, while drawstrings around the trousers helped to keep creepy crawlies out. Hybrid boots were introduced, consisting of a leather bottom half and quick-drying canvas on the sides.

ERDL camouflage, which is a mixture of shapes coloured either brown, green, beige or black which blend extremely well with the jungle environment, was also introduced to their uniform.

Many of these different innovations, along with the introduction of the M16 rifle, became a vital part to the soldiers who served in the Vietnam War.

Jungle combat

How US Army soldiers were equipped to fight through the challenging conditions

M1 helmet
Standard US Army issue since WWII, troops often customised their helmets with peace signs or playing cards

Armour
The soldier's zip-up flak vests provided protection and a means of storing ammunition and grenades.

M16 rifle
Replacing the heavy M14, this rifle was lightweight and produced a high rate of fire.

Utility belt
Fitted with a canteen and extra ammunition, these belts were heavy and cumbersome, but carried vital supplies.

Smoke grenades
The coloured smoke was used to provide cover, mark landing zones and identify the location of casualties.

Combat clothing
Made of tightly woven fabric, the olive-green clothing provided camouflage and protection from all weathers.

Boots
A leather and canvas boots enabled the feet to breathe and water to escape through drainage eyelets.

Above
British engineer Henry Mill was granted the first recorded patent for a typewriter in 1714

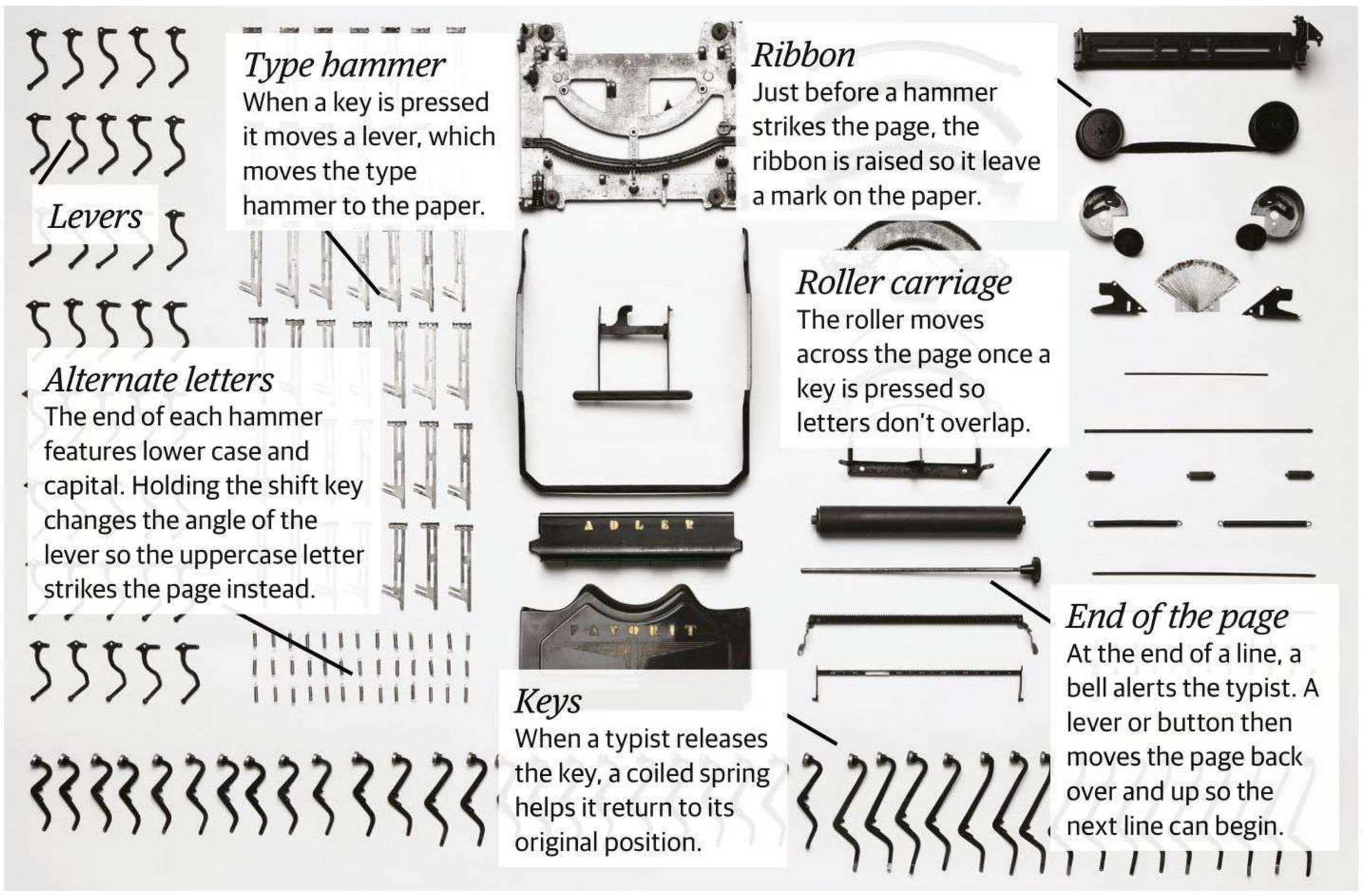
How did we type?

The origins of the writing machines that influenced modern keyboard designs

For most of the 20th century, almost every house, office and school had a typewriter. This mechanical device allowed people to write with neat, uniform text. Each key on a typewriter is connected via a lever to a type hammer, which has a corresponding symbol embossed on it. When a key is pressed, the lever swings the hammer towards the paper. A ribbon coated in ink is raised in front of the page, so that as the hammer strikes, it presses the ribbon on to the paper behind it, leaving an ink impression. The keyboard mechanism works in tandem with the carriage that holds the paper, moving along by the length of a key each time you type so the letters don't overlap.

Typewriter teardown

The components of a typewriter laid out and explained



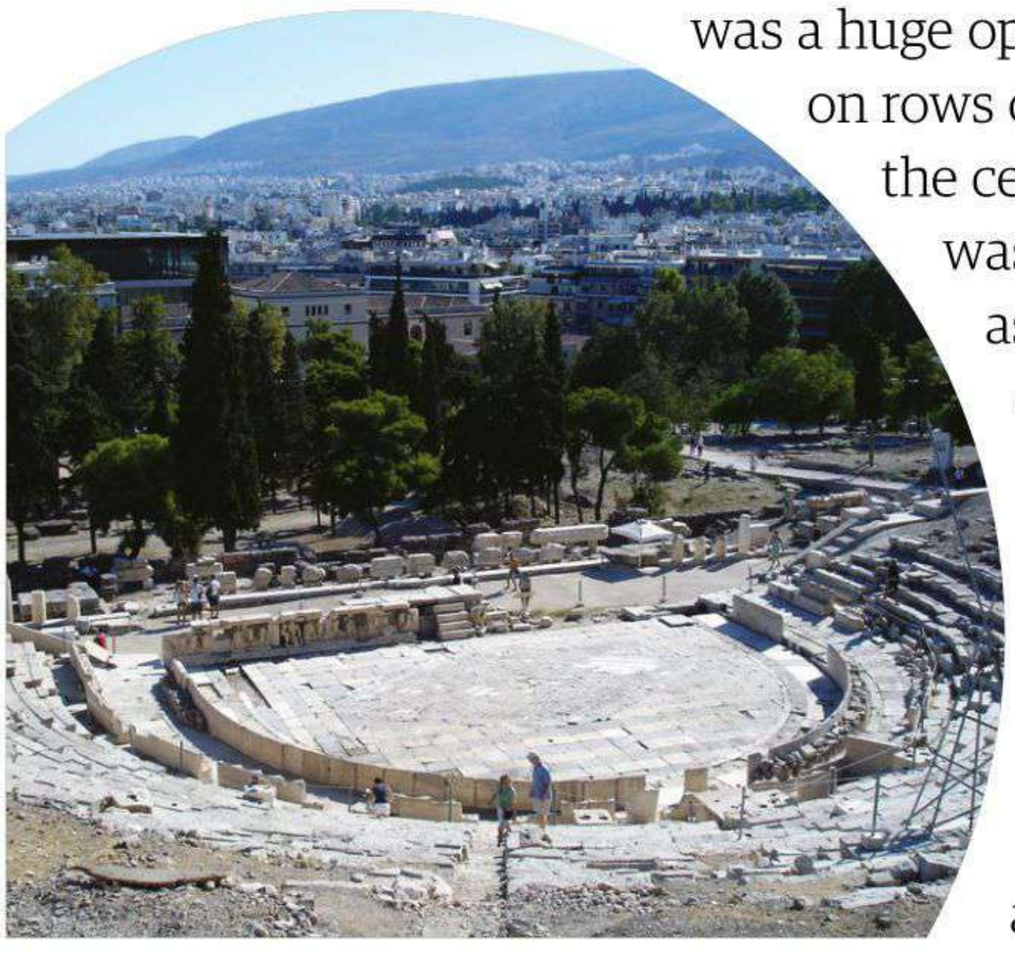
Why was the Ancient Greek theatre so popular?

Uncover the civilisation that invented the play and set the stage for Western culture

We have a lot to thank Ancient Greece for. From democracy to philosophy, this thriving collection of city-states was the birthplace of so many things that we take for granted today – including theatre.

The first mention of it dates back to 532 BCE, when an actor called Thespis performed a tragedy. His name has been immortalised as a term for a performer – a 'thespian'. A few decades later, a festival called the City Dionysia was established in Athens to honour Dionysus, the god of wine. The events centred on competitive performances of tragedies and, from 487 BCE, comedies. Thousands flocked from all over Greece, businesses closed and prisoners were released to take part in five days of festivities. Performances were staged at the Theatre of Dionysus, considered by many to be the first ever built. This was a huge open-air arena that could seat up to 17,000 people on rows of benches set into a hill. The actors performed in the centre, known as the 'orchestra', while a backdrop was painted onto a building behind the stage known as the 'skene'. This was also where the actors changed into their masks and costumes.

The theatre's acoustics were so well thought out that every single audience member would have been able to hear the actors performing, even in the days before microphones and sound systems. Over two thousand years later, we still base our theatre designs on these incredible ancient structures.



Below
The ruins of the theatre of Dionysus as they appear today

How to put on a play in Ancient Greece

Follow these steps to produce your very own dramatic masterpiece

1 Pick a genre

In Ancient Greece, tragedy and comedy should never mix. The City Dionysia pits the writers of these two genres against each other in its annual theatre competition, so choose a side and get planning.

2 Get funding

Plays in Athens are publicly funded, but you will need to pitch your idea to an official, who is known as the eponymous archon, and get his approval, before you see the colour of his money.

3 Decide your actors

The eponymous archon is responsible for deciding your lead actors, which is done by drawing random lots. The chorus actors are paid for by wealthy citizens looking to win public favour.

4 Start writing

Not only do your plays have to be written in verse, you'll also need to make sure you compose the music to accompany them. As for subject matter, the more revolutionary the better.

5 Perform your play

Once rehearsals are over, it's then time to bring your work to the big stage. The competitions can attract up to a staggering 17,000 people and can even last from dawn until dusk.

6 Collect your prize

The judges will then write their scores on tablets and place them in urns. The eponymous archon draws five of them at random and the winner is awarded with a wreath and a goat!

What was life like for a Victorian maid?

Discover the daily toils and troubles of a 19th century housemaid

In the large country homes and townhouses of Victorian Britain, it was a maid's job to be unseen and certainly not heard. That wasn't always easy when there was work to be done in every room of the house, and with gruelling shifts that were often 16 hours long. From the crack of dawn until the last drop of port had been drunk, a housemaid's day was filled with lots of cleaning and clearing, serving and sweeping.

Without modern-day appliances like vacuums and dishwashers to help them, this was no mean feat. Many suffered from ailments like 'prepatellar bursitis', an inflammation of the knee, caused by many hours spent scrubbing floors. Despite this, they considered themselves lucky to have a roof over their head, let alone a job. After all, sore knees were nothing compared to the horrors of the workhouse.

Maids were often recruited as young as eight years old and many came from the country, as they were considered more adaptable and harder working than children from the cities. A housemaid, who was responsible for general jobs around the house, earned about £16 a year – equivalent to a measly £960 ($1,370) today. On the plus side this included everything from board, lodging and all of their clothes, and when you were working seven days a week, there was very little time to spend money anyway. The work varied depending on the size of the household and how many servants there were. Each day had a strict routine, and there wasn't a single minute when there wasn't work to be done.

The daily routine

A Victorian maid's schedule was a never-ending list of chores

06:00 *Wake up*

Our maid wakes and quickly dresses. Her uniform is a simple black dress, a pinafore and a cap.

06:30 *Light the fires*

The carpets are swept and the fireplaces cleaned before new fires are lit. The family are then woken.

08:30 *Serve breakfast*

After eating her porridge, the maid brings out breakfast for the family. This often includes eggs, sausages and kippers.

10:30 *Make the beds*

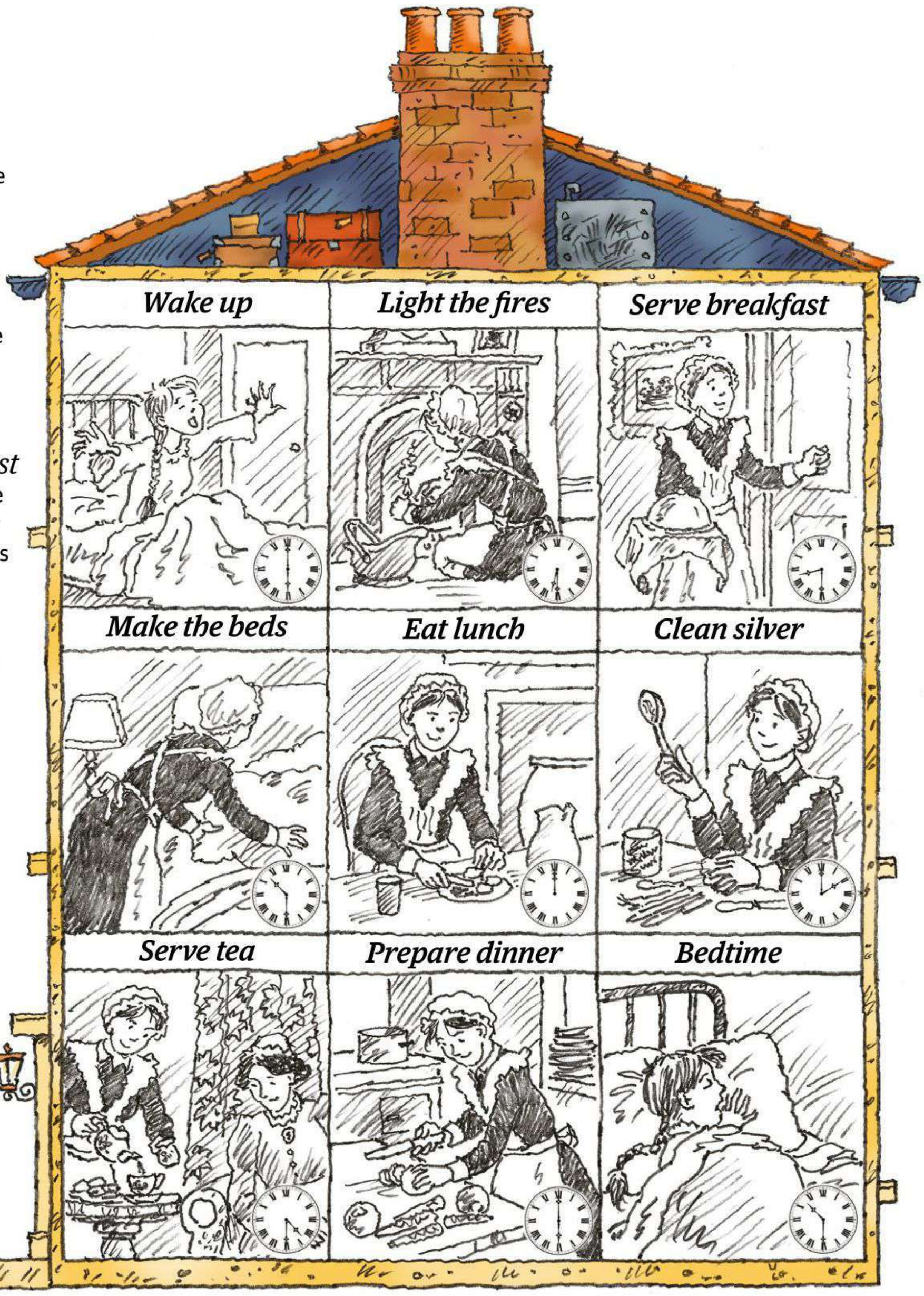
After clearing the breakfast table, it's time to clean the family bedrooms, make the beds and scrub down the bathrooms.

12:00 *Eat lunch*

The servants have their main meal at midday. It's usually a simple dish of meat and potatoes and a boiled pudding.

14:00 *Clean silver*

Once the family has eaten a three-course lunch, the table is then cleared, the dishes washed, and the silver polished.



16:30 *Serve tea*

Our maid has barely finished clearing up after lunch when the bell rings for afternoon tea.

18:00 *Prepare dinner*

The family eats dinner at 20:00, but before then there are vegetables to be chopped and a table to be laid.

22:30 *Bedtime*

When the dishes are washed, and after a quick supper of bread and cheese, it's finally time for bed.

When did the white flag become associated with surrender?

Where does this iconic symbol originate from?

Surrendering with the white flag is at least as old as China's Han Dynasty, dating to 25 to 225 CE, but it probably began even earlier. Roman historian Cornelius Tacitus also wrote about them in 109 CE, referencing white-flag use in a battle that took place 40 years earlier. White fabric was probably used because it was the easiest to obtain, and it also stood out against the landscape and other more colourful flags on the battlefield. Today using a white flag as a symbol of ceasefire, surrender or negotiation is part of the Geneva Convention.

Above
Give up? Then wave something white to signal your surrender

Who were the Mexican bandits?

Meet the outlaws who fought in the Mexican Revolution

Below
Pancho Villa (centre) dressed for battle with his revolutionaries

In 1910 Francisco Madero dared to challenge Díaz for power and the president had him jailed. However, Madero escaped from prison and called for his followers to revolt against the government. Armies of revolutionaries began to spring up across the country.

These gangs of bandits used all the firepower they could get their hands on to steal from the rich and give to the poor. They managed to successfully oust Díaz in 1911 but this didn't end the political unrest.

Madero was soon overthrown by Victoriano Huerta, who turned out to be even worse than Díaz, Groups began to turn on each other and even against the US, resulting in many bloody conflicts. Several leaders later, the revolution came to a close, but the legend of the Mexican bandits lives on to this day.

Ready for battle

The essential kit for Mexican revolutionaries

Bandolier
This long sash had several pockets for holding ammunition, ensuring it was always within easy reach for quick reloading.

Fiat money
Bandits began printing their own paper money to fund their cause. It was accepted as currency in the US all throughout the revolution.

Sombrero
Large hats helped to shield the bandits' eyes from the intense Mexican sun so that their view of the enemy wasn't ever obstructed.

Weapons
The bandits would use whatever arms they could get their hands on, with rifles proving a popular choice.

Horse
Travelling on horseback allowed for a speedy getaway and helped make the troops more mobile.

What happened to the British Isles during the Blitz?

The devastating eight-month long bombing campaign that pushed Britain to breaking point in World War II

Following RAF bombing runs on Berlin, Adolf Hitler declared that in retaliation against the British he would "erase their cities from the Earth." The Führer believed that a devastating bombing campaign concentrated on cities would break the morale of the British people.

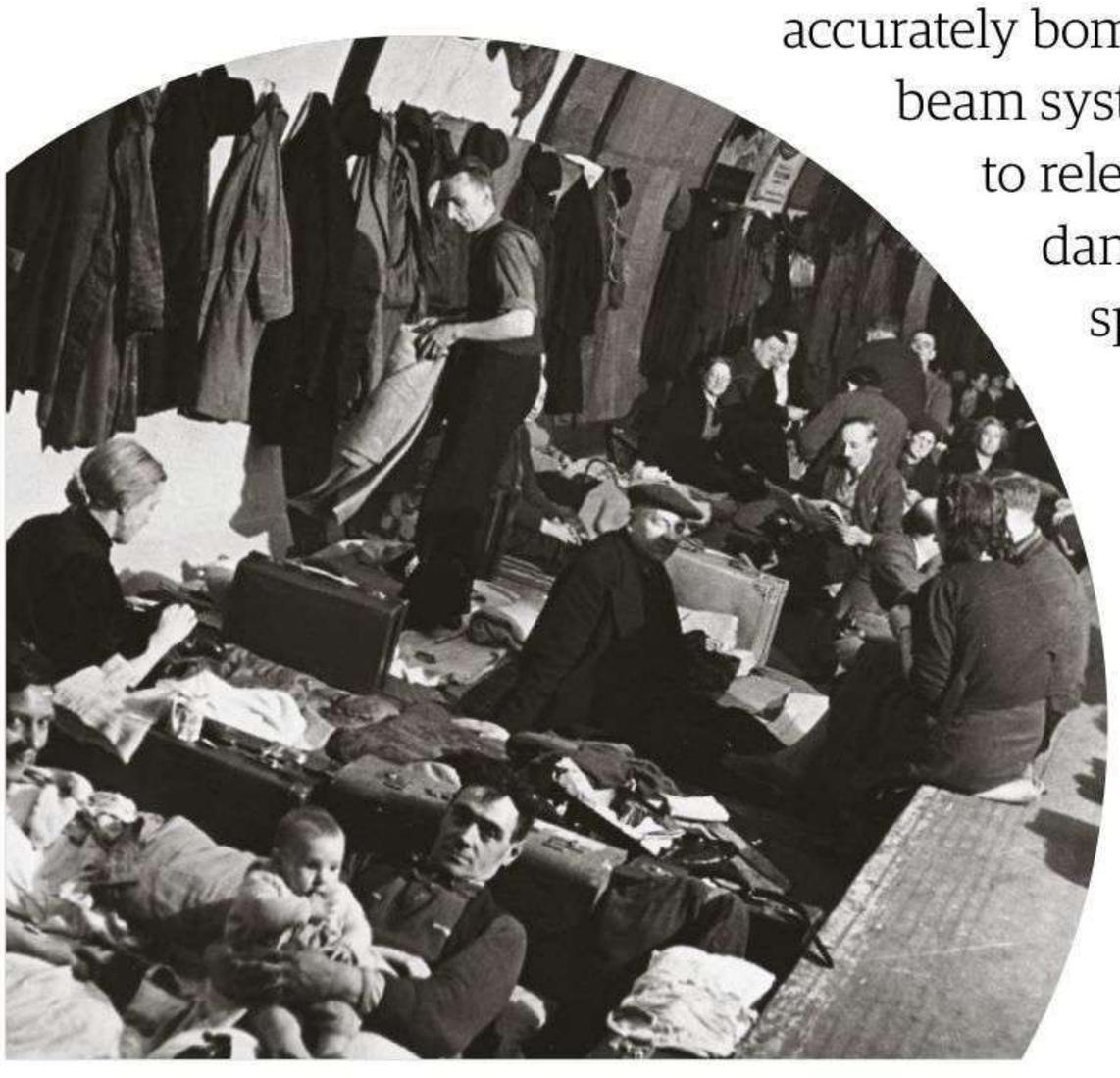
The Blitz began on 7 September 1940 as over 250 Luftwaffe aircraft dropped over 300 tons of bombs overnight on the capital. London would be bombed for the next 57 nights.

The British anti-aircraft guns didn't have the firepower to respond effectively and the attacks continued as cities like Coventry, Liverpool, Birmingham and Glasgow were also targeted. Approximately 150,000 people sought refuge in the London Underground every night while others took cover in corrugated iron Anderson shelters or simply hid under the stairs during the raids.

The Luftwaffe's Knickebein system used radio beams to accurately bomb targets. This later evolved into a four-beam system that had a clockwork timer for when to release the payload and cause maximum damage. The devastation continued until the spring of 1941, when on 10 May the biggest raid of the entire Blitz killed 1,436 civilians in one night.

Despite this, it became clear that the British could not be broken, even in the face of such heavy losses. As Hitler turned his attention east to an invasion of the Soviet Union, the bombing subsided. It was only in 1944, in the form of V1 and V2 rockets, that the attacks would return.

Below
79 underground stations were used as bomb shelters, but only 40 per cent of Londoners used them



The Blitz in numbers

September 1940-May 1941

INJURED 51,000

DEAD 43,000

HOMELESS 2.25M+

503 TONS

EXPLOSIVES DROPPED ON CITY OF COVENTRY

KEY: Tons of high explosives

1-499

500-999

1,000-2,000

18,800

Glasgow

Newcastle

Belfast

Manchester

Liverpool

Hull

Sheffield

Birmingham

Nottingham

Swansea

Coventry

Cardiff

London

Bristol

Portsmouth

Plymouth

Southampton

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Where did pubs originate from?

How foreign conquerors helped shape a British institution

Above
Taverns were hubs of drinking, eating and socialising

Below
Victorian gin palaces were lavish, gas-lit establishments that Charles Dickens described as "dazzling"

When the Romans invaded Britain in 43 CE, they brought with them all the trappings of civilised living: walled cities, literacy, sanitation – and pubs. Known as tabernae – the origin of the English word 'tavern' – these establishments sold wine to thirsty workers and soldiers. However, as the Romans left and the Anglo-Saxons settled in the British Isles, ale became the tipple of choice. Brewers opened up their homes as alehouses, and when the Normans conquered Britain in 1066, newly built monasteries began brewing their own beer to sell to weary pilgrims, while nearby inns offered refreshment and rest to travellers on the road.

Beer was often cleaner than water and cheaper than tea, with alcoholic drinking remaining widespread in Victorian Britain even after the temperance movement. These public houses – shortened to 'pubs' – featured beer engines that could pump the liquid from underground cellars to customers' glasses in seconds. As drinking cultures changed during the 19th century, venues diversified, but the British public hasn't called time on the traditional pub just yet.

How were Anderson shelters built?

These shelters protected millions during WWII

The Anderson shelter was designed to protect up to six people from bombings, and was made of curved, corrugated steel sheets. A shallow pit was dug in the ground, then the six steel sides were put in place and bolted together. The shelter's roof was covered in a thick layer of earth. By the end of World War II, more than 3.5 million of these structures had been erected throughout the UK.

Due to their corrugation, these shelters stood up to nearby bomb blasts surprisingly well. The explosive force of a bomb would easily buckle flat metal sheets, but the curved structure of corrugated steel absorbed this energy without sustaining a huge amount of damage.

To prevent the shelters from rusting, their steel sides were coated in zinc, a process known as galvanisation. Zinc reacts more readily with oxygen, which means it rusts instead of the iron and the shelter's walls remain intact. As a result, some Anderson shelters are still standing, over 70 years after the end of the war.

Inside the safe haven

See the design that withstood the Blitz attacks

Protective cover
Travelling on horseback allowed for a speedy getaway and helped make the troops more mobile.

Iron panels
Six corrugated steel sheets were bolted together to form the shelter's walls, with steel plates at either end.

Cramped conditions
Six people were expected to pile into a single shelter, which left little room once the air raids began.

Self-assembly
Supplied with only a flat pack kit, families had to build the shelters themselves.

Were there drones in WWII?

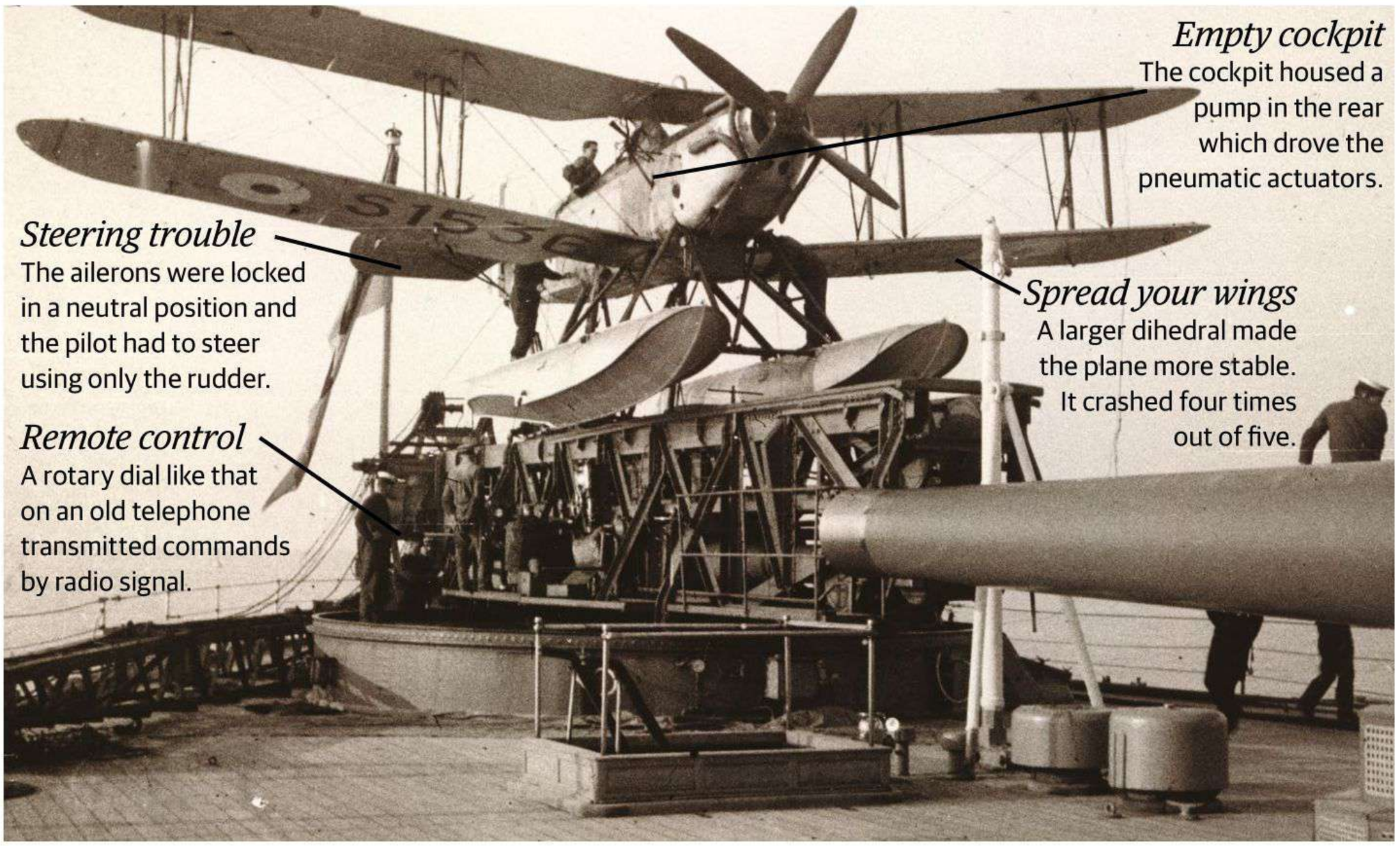
How UAVs first took to the skies over 70 years ago

In 1933, a modified floatplane called Fairey Queen was tested as the first ever flightless drone aircraft. It crashed on two out of three trials, but in 1934, Queen Bee, a modified Tiger Moth aircraft, followed with greater success.

Training gunners on these rudimentary models wasn't a very realistic simulation, but a solution was soon to come from the United States in the form of British-born actor Reginald Denny, and his Radioplane Company. After years of trying desperately to interest the US Navy in the Radioplane-1, Denny succeeded in 1939 and over the course of the war some 15,374 models of Radioplane were built.

Fast, agile and durable, fitted with responsive radio control and were able to mimic the speed and agility of the enemy's fighters.

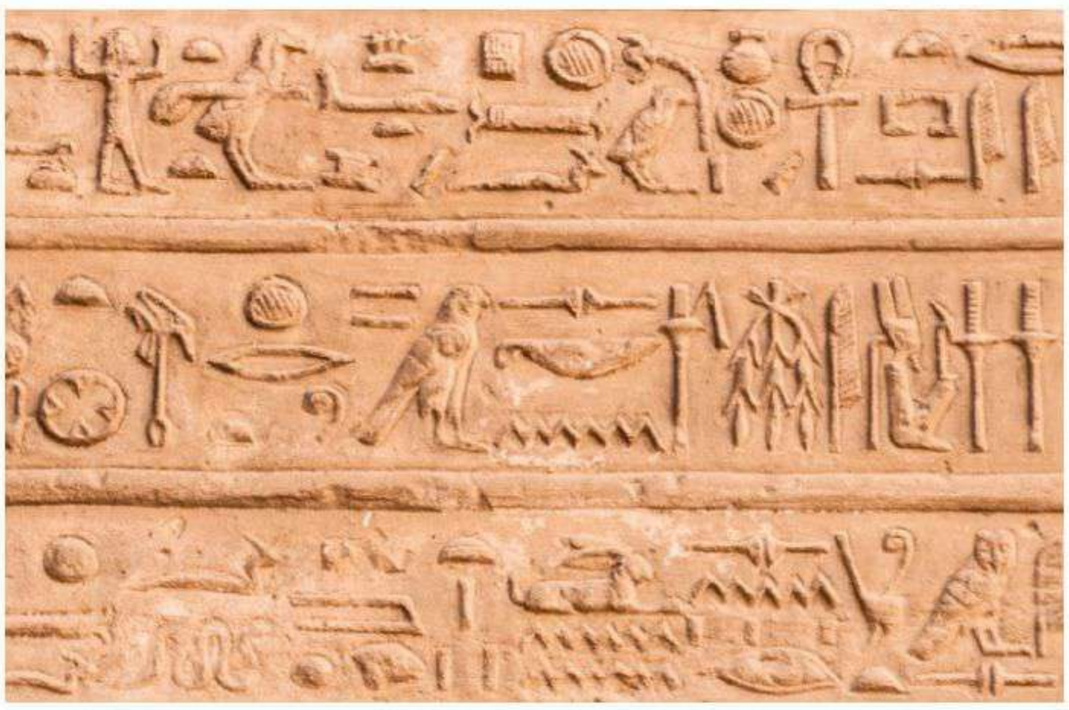
Beneath the hood of the first UAVs



Why do languages die?

What makes ancient languages go extinct?

Below
Many languages slowly died out as others started to dominate



There were once an estimated 20,000 different languages spoken throughout the world, but now there are less than 7,000 remaining. The most common way a language becomes extinct is when one language spoken by a bilingual nation becomes more socially dominant than the other. If someone is more likely to find a job or make friends speaking a particular language, then they are likely to favour that one and ultimately drop any others that they can speak. Alternatively, the two languages may gradually merge into one, as the minority language borrows more and more words, phrases and grammar from the dominant one until they eventually become inseparable.

What was the first country to have a democratic election?

Where did our democratic system originate?

Right
A democratic society must hold free and fair elections

The word democracy, meaning 'rule by the people', originated in Ancient Athens, but women and slaves could not vote. There's evidence that democratic societies existed in India even earlier. Some argue that the first true national democratic election was in Finland in 1906, when citizens of both genders could vote and hold government positions. Women could already vote in some places, but not hold office.

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What did a 19th century fireman look like?

How the USA's volunteers put the fight in firefighter

During the late 18th century and early 19th century, firefighters in the USA didn't have such a good reputation. Firehouses were like social clubs and when news of a fire broke, the volunteers would race other fire companies to the scene. These competitions often resulted in the firefighters battling each other instead of the fire!

By the mid-19th century, insurance companies and Republican Party were lobbying for a professional fire service. When horse-drawn, steam-powered water pumps became available, volunteers were replaced with paid fire departments.

Below
Firehouses were often like social clubs, with firefighters made up of volunteers

Firefighters

Learn the anatomy of a 19th century fireman

Helmet
The reinforced dome helmets made from specially treated leather had an angled brim so that water could run off the back.

Speaking trumpet
Excited and noisy crowds would often come to watch the firefighters at work, so they used brass speaking trumpets to relay commands.

Beard
Firefighters would soak their beards in water, bite them, then breathe through them to prevent themselves from inhaling fumes from the fire.

Red shirt
Bright red, bibbed shirts helped people identify the firefighters, and they soon became a symbol of elevated social status.

Hose
The leather hose had seams held together by metal rivets to stop it rupturing under the pressure of the water.

Leather boots
Knee-high leather boots were worn mainly to keep the firefighters warm and dry, rather than protect them from the flames.

Why was the Sikorsky MH-60 Black Hawk perfect for war?

A war machine built for a new kind of battlefield

Below
The Black Hawk is capable of carrying a range of weaponry, and will often house a door gunner for protection in hostile environments

Two US companies, Boeing Vertol and Sikorsky, went head-to-head with their rival designs for the new combat helicopter, with the latter winning the contract with its S-70 prototype.

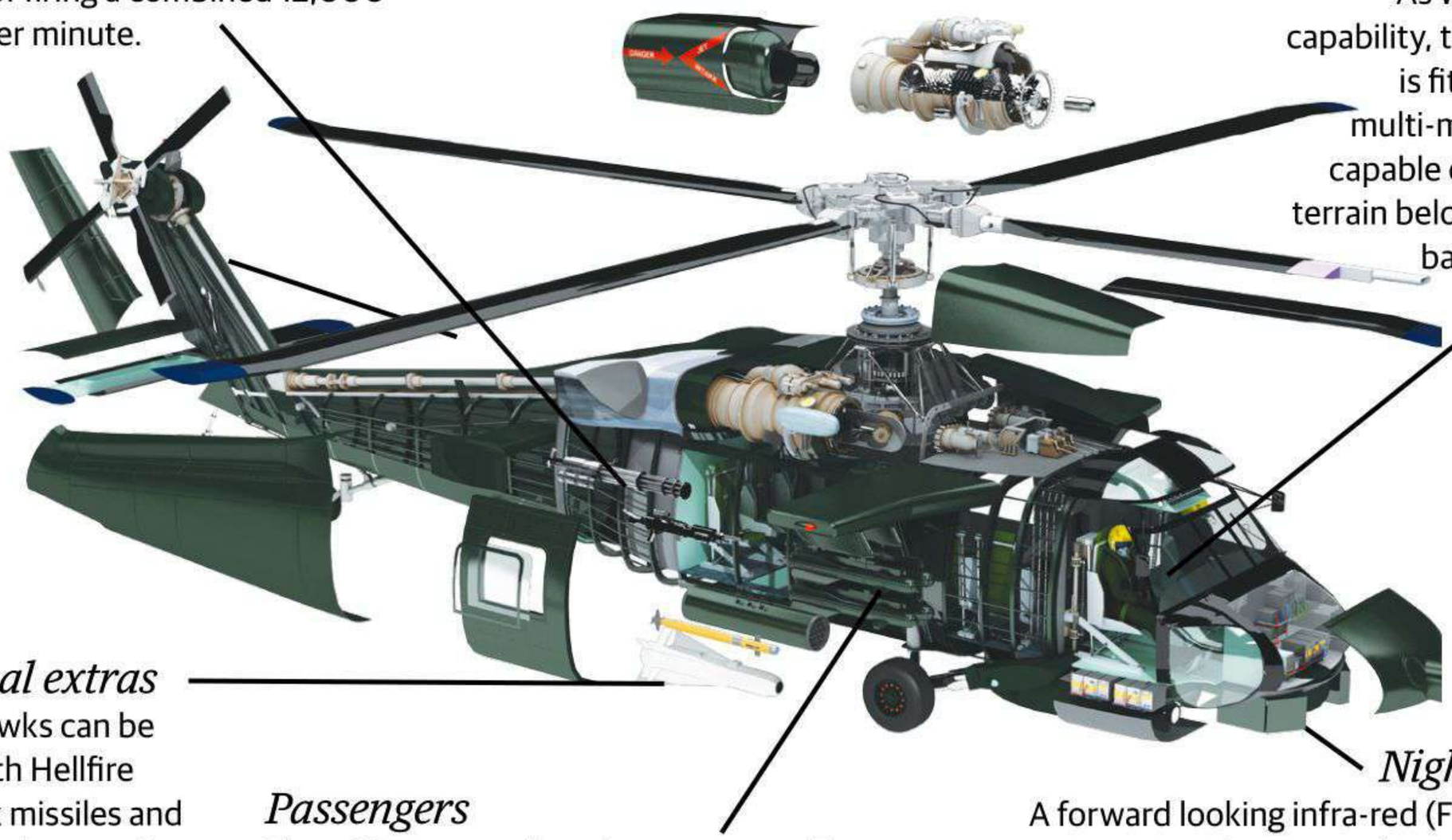
The MH-60 variant seen here was developed from the standard UH-60 Black Hawk for use during special operations. The machine's effective range was greatly increased with the addition of a more efficient fuel tank, the installation of systems for aerial refuelling, and the improvement of the craft's overall survivability. It was during a special operation that these assets would be put to the ultimate test, an incident known as Black Hawk Down.

Inside a Black Hawk

The high-powered tech behind the MH-60 military machine

Machine guns
Two electrically powered M134 Miniguns, capable of firing a combined 12,000 rounds per minute.

Radar
As well as GPS capability, the MH-60 is fitted with a multi-mode radar capable of tracking terrain below, even in bad weather



Optional extras
Black Hawks can be fitted with Hellfire anti-tank missiles and rocket pods, as well as additional fuel tanks for long-haul missions.

Passengers
Up to 18 personnel can be transported in the rear of the aircraft, which has an operational range of over 2,200km.

Night vision
A forward looking infra-red (FLIR) video camera pod captures the surrounding environment and relays it to the pilot, enabling safe flight in total darkness.

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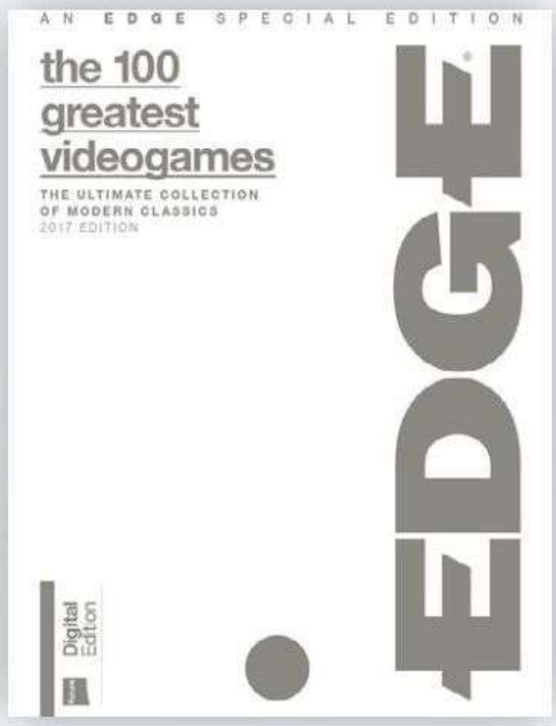

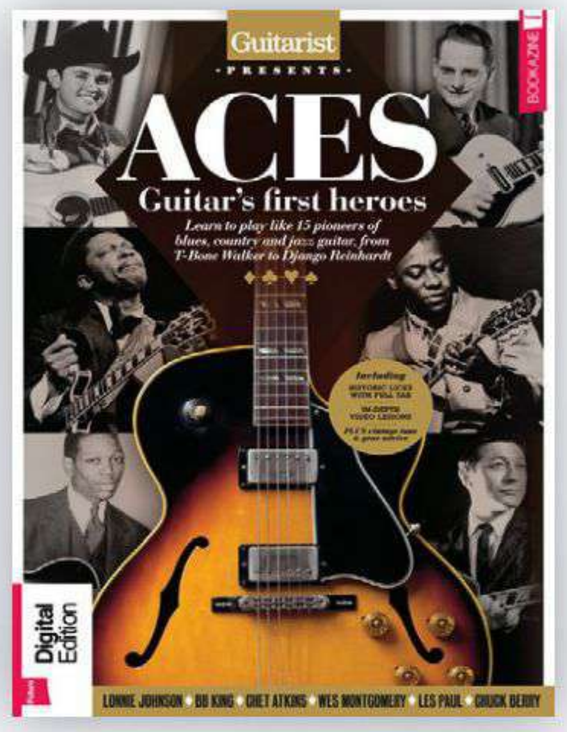

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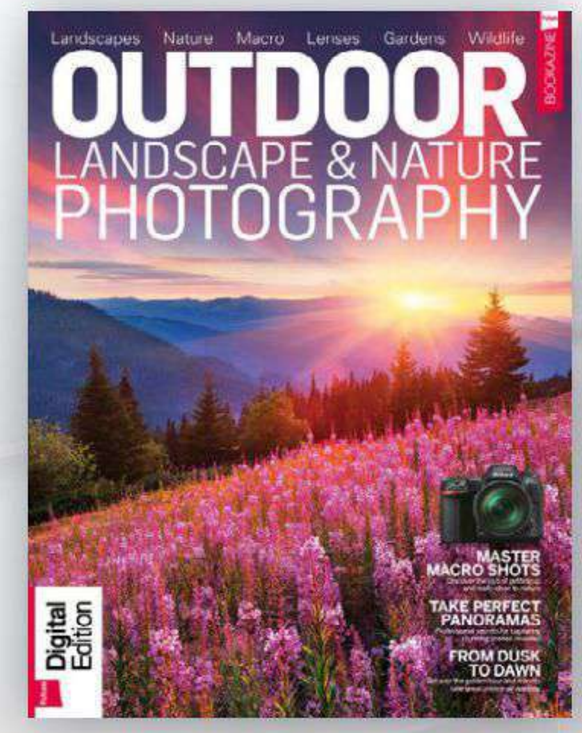

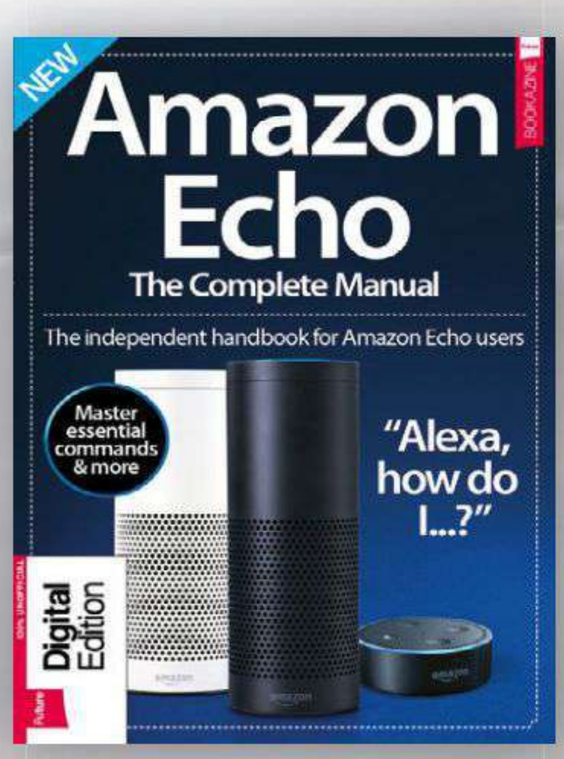

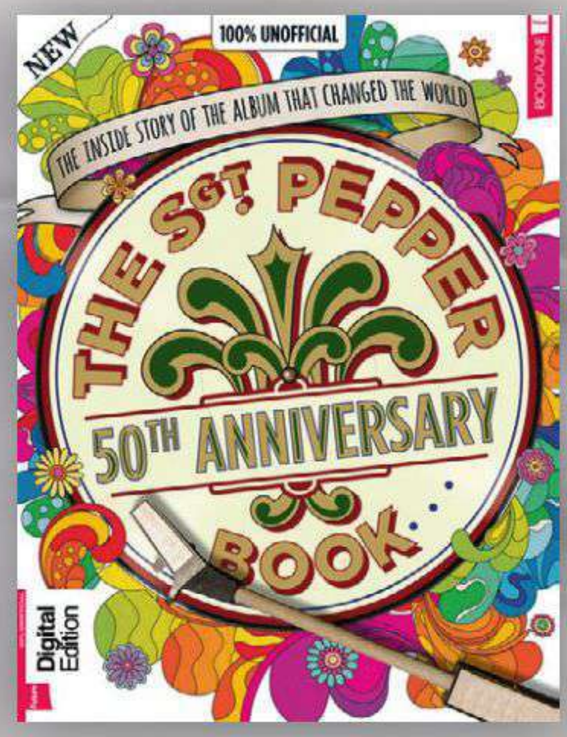

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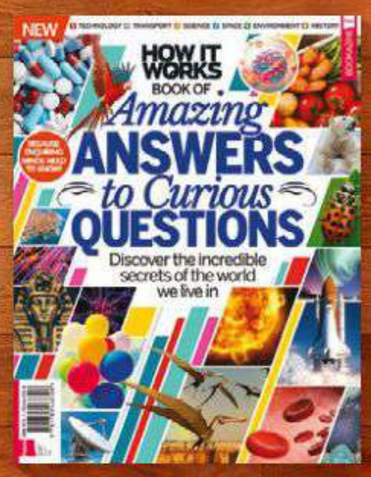

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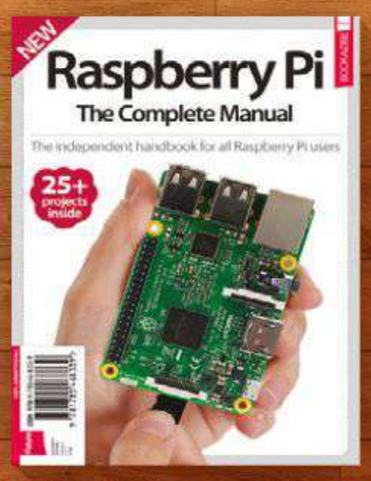

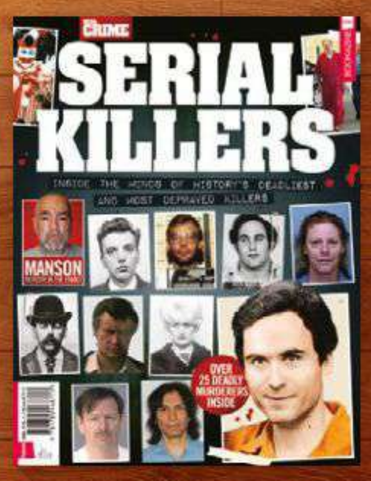

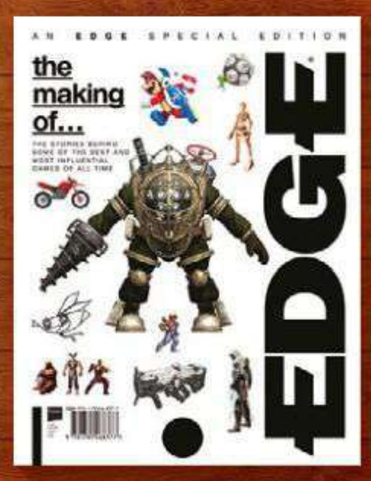

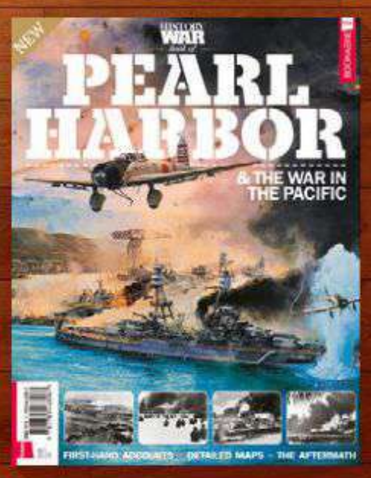

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